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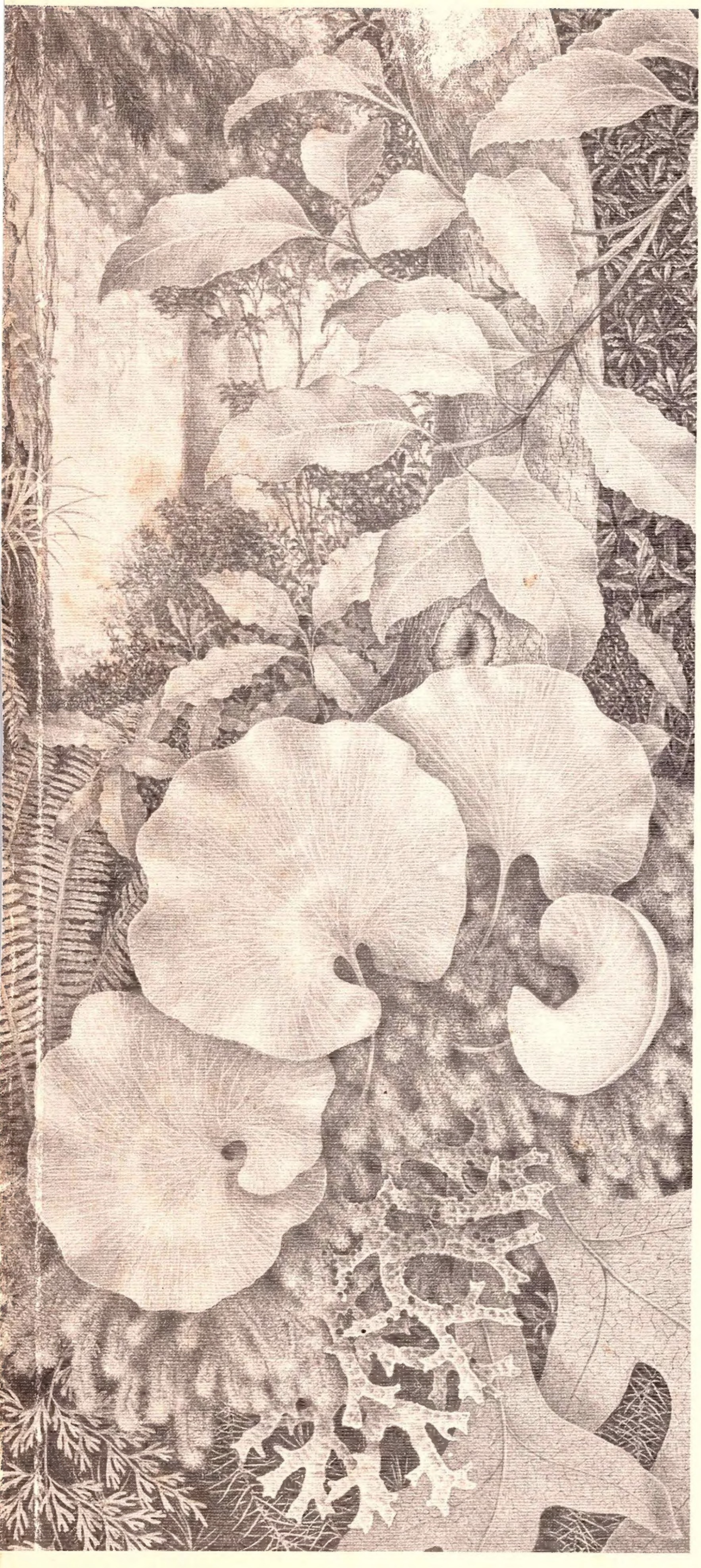

Plants and Landscape in Westland National Park

by
Peter Wardle

Illustrations by
Keith West

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Plants and Landscape in Westland National Park is the third in a series which presents the results of major resource and scientific studies in New Zealand national parks. The series is published by the National Parks Authority, but much of the work is promoted by the national park boards which administer individual parks.

The National Parks Act 1952 directs that the parks are to be preserved as far as possible in their natural state. The research work published in this series will therefore provide park administrators with valuable guidance for policies and management decisions; it also gives base-line information to help determine the extent and nature of environmental changes outside national park areas.

The author of this publication, P. Wardle, M.Sc. (N.Z.), Ph.D. (Cantab), F.R.S.N.Z., is an ecologist with Botany Division, Department of Scientific and Industrial Research, at Christchurch and the illustrator, K.R. West, is senior artist at the same institution. The vegetation survey of Westland National Park was carried out between 1964 and 1974. Results have been presented in scientific papers (see References) and as unpublished reports to the Westland National Park Board.

Dedicated to the memory of Peter Fletcher (Chief Ranger, Westland National Park) and James Maitland (park board member) who died in an accident on the Copland Pass on 26 March 1977.

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Acknowledgement
Satellite photograph of the Alpine Fault and the West Coast between Makawhio Point and Kumara Junction, just south of the Taramakau River, p. 4.
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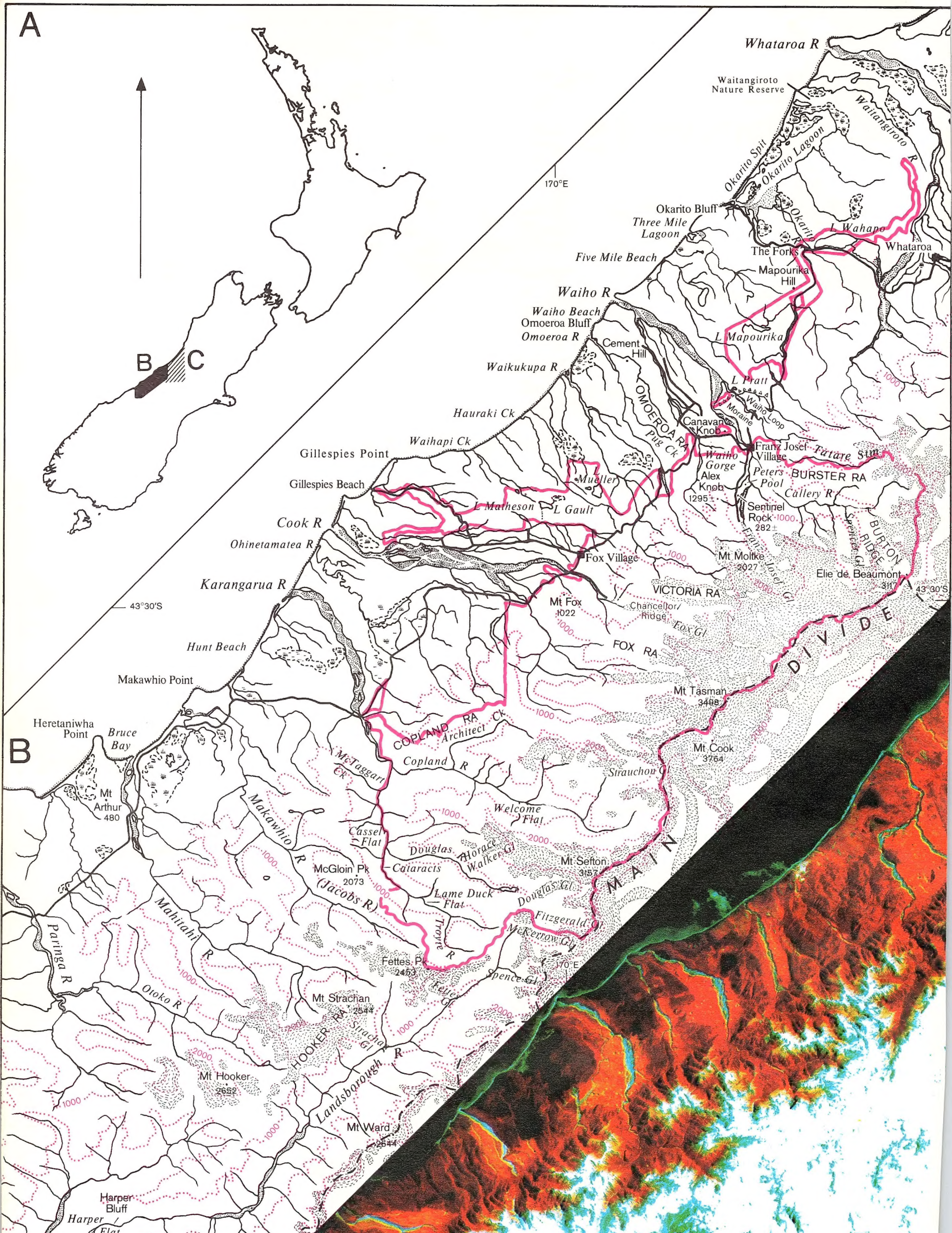
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170°E
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Whataroa R
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Okarito Spit
Okarito Lagoon
Okarito Bluff
Three Mile Lagoon
Okarito R
L Wahapo
Whataroa
The Forks
Mapourika Hill
Five Mile Beach
Waiho R
Waiho Beach
Omoeroa Bluff
Omoeroa R
Cement Hill
L Mapourika
Waikukupa R
OMOEROA RA
L Pratt
Waiho Loop
Moraine
Hauraki Ck
Canavan Knob
Pug Ck
Franz Josef Village
Tatare Stm
Waihapi Ck
Gillespies Point
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Alex Knob
1295
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BURSTER RA
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Callery R
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MAIN DIVIDE
Makawhio Point
Mt Tasman
3498
Heretaniwha Point
Bruce Bay
COPLAND RA
Architect Ck
Mt Cook
3764
2000
Mt Arthur
480
McTaggart Ck
Copland R
Strauchon Gl
Makawhio R
Welcome Flat
Cassel Flat
Douglas
Horace Walker Gl
Mt Sefton
3157
McGloin Pk
2073
Cataracts
(Jacobs R)
Lame Duck Flat
Douglas Gl
Mahitahi R
Fitzgerald Gl
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2453
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Mt Strachan
2544
Strachan Gl
HOOKER RA
Mt Hooker
2652
Landsborough R
Mt Ward
2644
Harper Bluff
Harper Flat
5 km

Introduction

New Zealand is a land of contrasts, and nowhere is this more true than in Westland, where ice-clad peaks and lush, evergreen lowland forest are mirrored together in deep, dark lakes that fill troughs carved by ancient glaciers. The summit of the highest peak, 3498-m Mt. Tasman, is less than 27 km from the sea, but despite the ruggedness, the landscape reveals a consistent pattern from Arahura in the north to Paringa in the south. This long, narrow land lying between the Main Divide and the sea consists of two parallel segments which are divided by a major break in the earth's crust known as the Alpine Fault (p. 4). The Southern Alps form one of the segments. They consist of greywacke and schist rocks and rise steeply from the south-eastern side of the fault to reach their greatest elevations in Mount Cook and Westland National Parks. The flanks of the ranges and the floors and sides of the valleys that dissect them are clothed in forest which merges into thick scrub above about 900 m above sea level. The scrub in turn gives way to grassland, and this is replaced by alpine barrens and snow fields above 1700 to 2000 m.

The segment north-west of the Alpine Fault is much lower and will be referred to as **piedmont** (Fig. 1). The solid rocks are greywackes and granites and mostly are buried beneath sediments derived by erosion of the Alps, but they rise as hills here and there, notably in the Omoeroa Range which reaches 682 m above sea level. Otherwise, the piedmont area consists of alternating stretches of rolling or steep forest-clad hills and flat valleys traversed by braided rivers flowing in wide gravelly beds. Road cuttings show the hills to be composed largely of moraine, deposited by ice-age glaciers which extended beyond the present coast.

The soils on these moraines are leached and infertile and in some places, especially on the plateaux between the Waiho and Cook Rivers, are not capable of supporting continuous forest; instead there is boggy ground with scrub, tussock, fern, and rush-like plants. In other places, the forest has been burnt, and, being very slow to re-establish on these soils, its place is taken by the boggy clearings known as pakihis.

The river valleys represent the troughs carved by the great glaciers during their final extension. These have been subsequently filled with gravel, silt, and peat, although unfilled portions remain as the lowland lakes; those of Westland National Park being Wahapo, Mapourika, and Matheson. The young, stony river flats have open grazing land, though if permitted they would gradually become covered in scrub and, finally, forest. Soils above flood level, where well drained and not too stony, now support Westland's farms — only fragments of their original forest remain. There are extensive swamps and still-considerable tracts of forest on wet ground, especially towards the mouths of the major rivers.

The coastline describes long sweeping curves between promontories where the sea has cut bold cliffs from moraine. The rivers, both large and small, meet the sea via

Fig. 1 The foreground is rolling piedmont moraine, south of Omoeroa River. Manuka (*Leptospermum scoparium*) scrub with some pink pine (*Dacrydium biforme*) occupies the hollows, while forest, largely of rimu (*D. cupressinum*) and rata (*Metrosideros umbellata*), grows on the well-drained ridges. The Omoeroa Range, consisting of hills of granite and greywacke, forms the skyline in the centre and to the left. The snow-clad Burster Range of the Southern Alps is on the right.

lagoons impounded behind gravelly beach ridges. Several of these lagoons are extensive, Okarito, the largest, covering 2500 ha.

A thousand years ago New Zealand was unknown to man. In every other habitable region of the earth, save a few remote islands, man had tilled the soil, built cities, or hunted animals, many of them to extinction, and had changed forests into grasslands and grasslands into deserts. But in New Zealand, evergreen forests of podocarps and beeches stretched from shore to timberline, and flightless birds knew few enemies. The coming of the Maoris changed much of this. Their cultivations were of limited extent, especially in the south, but by A.D. 1400 their fires had swept most of the forest from the drier parts of the country, and moas had become extinct together with the eagle that preyed on them.

West of the Southern Alps, however, the forest was tenacious under a rainfall of 3000 mm and more, and leached soils and cool summers did not permit cultivation

of the Polynesian food plants. Gravel beaches pounded by heavy surf were a poor habitat for shellfish, and the coast was too dangerous for off-shore fishing. Relative plenty existed only in the brackish lagoons, especially in the form of inaka (or white-bait) migrating from the sea to the rivers during early summer in runs of a magnitude no longer seen. Inland, there were birds and giant eels in the peat-stained water of lakes and sluggish streams. The Maori population of Westland was therefore small and concentrated in the north whence the greenstone of the Arahura Valley was traded throughout New Zealand via trans-alpine passes to Canterbury and via the Grey and Buller Rivers to Nelson. There was also a route southwards along the coast and thence through passes to Otago, but there was scarcely a permanent settlement on the west coast south of Arahura.

Maori influence was therefore minimal in the area which is now Westland National Park, although hunting of birds and the introduction of dogs and rats from Polynesia may have had some indirect effects on plant life. Direct changes in the vegetation through the activities of the Maoris were largely confined to coastal places, especially the wider sand spits confining the lagoons. When Haast travelled down the coast in 1865, evidence of Maori habitation was still apparent at the mouth of the Waitangiroto River and on Okarito Spit. Over the centuries, they doubtless cleared areas of sand country through fire, perhaps to encourage growth of bracken fern. Dense flax capping the seaward ends of moraine ridges possibly first grew up after forest was

burnt to facilitate travel along the coastal trail, and perhaps the large pakihis inland from Okarito were first cleared of scrub by eeling parties bound for Lakes Wahapo and Mapourika. Although the South Island Maoris were persistent explorers, the alpine part of the district would have held little interest for them, especially as the Main Divide presented a barrier without a single snow-free pass for 120 km.

Gold fever in the 1860s led to the first massive human influence. The earliest diggings were on the beach ridges which separated the coastal lagoons from the sea, and small towns sprang up at Okarito and Gillespies Beach. The main activity was over in a few years, and despite a revival of dredging in the 1930s, the coastal townships became all but abandoned, and the scars of mining are disappearing under gorse and flax. There were smaller gold workings inland — at The Forks, Waiho Gorge, and the junction of the Cook and Balfour Rivers — but these too have been reclaimed by the forest.

However, mining led to improved access, first as tracks leading from the port of Okarito, and eventually, during the present century, by road from the north. This made farming of the valley flats of the Waiho, Cook, and Karangarua Rivers feasible. Cattle grazing began on flood plains which had not yet developed their cover of forest, but the settlers soon began extending their pastures by felling the forests of matai, kahikatea, and totara that grew on the alluvial sites. At first most of the timber was burnt, but eventually sawmilling began, and even now farmland is extending in the wake of logging. Outside the three main valleys, there is grazing on the beach ridges at Okarito and Gillespies and on small flats along the Omoeroa and Waikukupa Rivers. In the mountains, cattle have been grazed at Cassel Flat in the Karangarua Valley from time to time, and sheep were depastured on the alpine grassland of the Copland Range for a few years around 1900.

While farming and sawmilling have had the greatest obvious effects on the vegetation in the district, tourism is probably now the most important economic activity, for the Franz Josef and Fox Glaciers are billed as two of New Zealand's main scenic attractions. Tourism may be said to have begun in 1872 with the visit by Sir William Fox, then the colony's Prime Minister. In the year 1971-1972, nearly 600 000 visitors to Westland National Park were recorded.

There is still an essentially virgin landscape inland from the West Coast highway, the three farmed valleys, the two townships, and the roads which pursue the retreating Franz Josef and Fox Glaciers. Even after 1890, when the pattern of settlement was already established, Charles Douglas, the Government Explorer, and his assistant A.P. Harper were making the first recorded visits to various mountain valleys. Over the years, tracks were cut up the valleys, only to be overgrown after a few years of neglect. The real colonists of the alpine country have been red deer, which depleted the forest undergrowth as they spread northward from Lake Hawea, where they were released in 1871. Deer, with the help of chamois and thar, have even defeated the redoubtable mountain scrub over large areas. However, browsing mammals were preceded many years earlier by small predatory ones. Douglas, like Albert Henry in Fiordland, sadly watched the native birds disappear as cats and stoats spread through the forest. Kakapo, saddleback, kokako, and native thrush are long extinct in Westland.

Wekas survived in the upper reaches of the Karangarua River system and now seem to be spreading northwards again. Kiwis, robins, and parakeets occur only locally, while kakas although widely distributed are no longer abundant. Nevertheless, there is still a considerable variety of birdlife. The chorus of bellbirds and tuis still greets the dawn, augmented now by the European blackbird which has penetrated to the most remote forests. In the mountains, keas persecute the visitor as cheerfully as in Douglas's time.

Westland National Park was founded in 1961 to mark the centenary of Westland, its nucleus being scenic reserves which had been gazetted from 1911 onwards to include the main glaciers and the two large lakes, Wahapo and Mapourika. The park now includes nearly 90 000 ha of mountains, glaciers, lakes, and forest, but this book describes a still larger area, for the whole expanse from the crest of the Alps to the Tasman Sea forms a natural unit. The unity is expressed in the geology of uplifted schist mountains, and the lowland moraines and alluvial valleys which have been eroded from them; in the hydrology of snow, glacial ice, river, and coastal lagoon; and in the biological sequence from alpine barrens to intertidal boulders.

Throughout this book, plants are briefly described as they are introduced in the narrative. With the aid of accompanying drawings*, and the fuller descriptions in Appendix 2, visitors should be able to recognise the more common plants as they meet them in their natural setting. However, as over 700 distinct species and varieties of ferns, conifers, and flowering plants grow in and near Westland National Park, all but 100 of them being native, those who wish to acquire more extensive knowledge will need to refer to books which describe the New Zealand flora in greater detail.

Much of the beauty and interest of the vegetation, especially in the forest, lies in the so-called lower plants, including mosses, liverworts, lichens, and fungi. For these, well-illustrated introductory books have recently been published, but accurate identification is still a matter for the specialist.

The first of the six chapters of this book describes the climate, and how it influences the distribution of plants geographically and within communities. Chapter 2 relates soil to vegetation and discusses how both develop and change with the passage of time. The next two chapters describe the vegetation on low-lying areas in the river valleys and on the coast. Chapter 5 traces the development of the landscape and the history of the plants from their earliest fossils in our rocks, through their vicissitudes during the ice ages of the last 100 000 years, to their adjustments to the climatic fluctuation of recent centuries. The final chapter looks at the condition and future of the vegetation in relation to the changes set in train by the arrival of man.

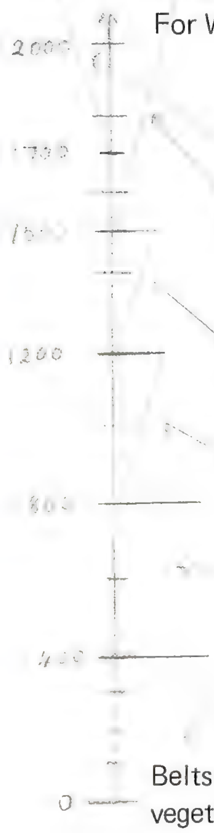
* Plants are drawn life-size, except where a scale is indicated in the legend.

1

Climate and vegetation

Altitudinal zonation

In Westland, the original native vegetation still covers most of the land, and it is obvious even to the most casual observer that there is a broad zonation from the forest of the valleys, hills, and lower slopes, through mountain scrub and grassland, to the alpine wastes of rock, snow, and ice. This sequence is caused by the decrease in temperatures with increasing altitude. Since plants need warmth for growth, lower temperatures result in shorter, less vigorous vegetation. Botanists have defined several altitudinal belts mainly according to the upper altitudinal limits of common plants. For Westland, these are very approximately as follows:



Belt	Altitude	Vegetation
Nival	Down to 1700 m on south aspects	Lichens on snow-free rocks
High-alpine	1500 m to above 2000 m on north aspects	Short grassland and herb field
Low-alpine	1200 to 1500 m	Tall grassland and low scrub
Subalpine	800 to 1200 m	Dense scrub and low forest
Montane	400 to 800 m	Forest
Lowland	Up to 400 m	Forest with abundant lianes and epiphytes.

Belts rise in altitude towards the equator, so that in New Guinea, for example, vegetation similar to the lowland forest of Westland appears at about 2500 m above sea level, whereas in the Auckland Islands the vegetation at sea level is like that in the subalpine belt of Westland.

The lowland forest of almost subtropical luxuriance which once covered much of the North Island, and which is still well developed along the West Coast north of the Gray River, is somewhat attenuated in South Westland because many of its distinctive

species do not reach so far south; examples are the nikau palm (*Rhopalostylis sapida*), northern rata (*Metrosideros robusta*), pukatea (*Laurelia novae-zelandiae*), and the big epiphytic lilies of the genus *Collospermum*. However, other northern plants occur where conditions are mild. Kiekie vine (*Freycinetia banksii*), a relative of the tropical pandanus, runs rampant on the coastal hills and north-facing slopes of the main piedmont valleys, smothering the ground and lower parts of trees with impenetrable masses of thick, springy stems and long cutting leaves (Fig. 2). Puka (*Griselinia lucida*, Fig. 3), an epiphytic shrub with large, glistening leaves, is conspicuous in the crowns of podocarp trees growing in warm sites. A bracken (*Pteris macilenta*) and the sedge *Carex solandri* (Fig. 35) are confined in South Westland to patches of forest on the coastal cliffs. Mamaku (*Cyathea medullaris*), the largest of our tree ferns, recognisable by the thick, black stalks of its fronds, mainly grows along the same coastal cliffs, although there is a large inland grove in the gorge of MacDonalds Creek. A tall, slender tree fern, *Cyathea cunninghamii*, occurs just above the floors of the major river valleys where they emerge from the mountains. For kawakawa (*Macropiper excelsum*), a shrub closely related to the kava-yielding plant of the tropical Pacific, the southernmost known station in Westland is on Okarito Bluff.

The most extensive kind of forest is that clothing the cooler hill slopes in the piedmont region and the less precipitous slopes in the mountains up to the middle of the montane belt (Fig. 2-8). Seen in profile (e.g., where a road has been newly cut) it presents a distinctly storied appearance. The large, straight-boled trees which form a rather open canopy at 25 to 35 m are podocarps or southern hemisphere conifers which have cones modified into fleshy, berry-like structures attractive to birds. The most numerous podocarp on the slopes is rimu (*Dacrydium cupressinum*), recognisable by its bronze, pendent branchlets. Hall's totara (*Podocarpus hallii*) and miro (*P. ferrugineus*) are also common. The main canopy is formed at 15 to 25 m by broad-leaved trees. Kamahi (*Weinmannia racemosa*), by far the most abundant of these, has dark-green, finely serrated leaves and racemes of small white flowers which are conspicuous in the early summer. Other canopy trees are southern rata (*Metrosideros umbellata*), renowned for its display of red flowers, and Westland quintinia (*Quintinia acutifolia*) with light-coloured leaves crinkled at the margins.

Smaller trees occur beneath the main canopy, typical species being matipo (*Myrsine australis*), pigeonwood (*Hedycarya arborea*), lancewood (*Pseudopanax crassifolius*), and three-finger (*P. colensoi* var. *ternatus*, Fig. 12). There are also shrubs, most of which have tiny leaves and slender stems, which divaricate (i.e., branch repeatedly at wide angles). Examples are *Neomyrtus pedunculata*, which has small white flowers, *Coprosma ciliata*, and *C. rhamnoides. Coprosma lucida*, on the other hand, has the larger, glossy leaves so characteristic of New Zealand trees.

Cyathea smithii, a tree fern with fronds soft to the touch, and the harsh tree fern *Dicksonia squarrosa* occur on most sites. Medium-sized ferns form a more-or-less continuous understorey, the main species being crown fern (*Blechnum discolor*) which has the appearance of a miniature tree fern in that its fronds are borne at the tops of stems about 50 cm tall.

The lowest stratum of the forest contains small plants clothing bases of trees and fallen logs and growing patchily on the forest floor. They are insignificant in terms of mass of living tissue but total far more species than the rest of the forest community put together. Filmy ferns (family Hymenophyllaceae) are the most obvious and have finely divided fronds that are only one cell thick between veins; but one species, kidney fern (*Trichomanes reniforme*) has thicker, undivided leaves. Mosses and liverworts are generally smaller, but, here and there, colonies of *Dawsonia superba* will be met. This giant of the moss world has stems up to 30 cm tall, with needle leaves 2 cm long. The genera *Nertera* and *Uncinia* are also represented. The former are small, creeping flowering plants with red berries, and the latter are the "hook-grasses" which are actually sedges named for their hooked seeds which cling annoyingly to hair and clothing. Fungi include the striking little toadstool *Entoloma hochstetteri* with its bright blue pixie cap.

Lianes are a distinctive feature of the hill forests, the most abundant and widespread species being supplejack (*Ripogonum scandens*) with black cane-like stems, the prickly leaved bush lawyer (*Rubus cissoides*), and rata vines (*Metrosideros*). *M. diffusa* and *M. perforata* have white flowers, and *M. fulgens* has showy red flowers which appear during late summer, autumn, and winter (Fig. 9-10). Epiphytes are also numerous and include not only mosses and filmy ferns but also larger plants, such as the lily *Astelia solandri*, ferns, orchids, and seedlings of various trees, including kamahi, rata, broadleaf (*Griselinia littoralis*, Fig. 3), and three-finger. The roots of these young trees eventually grow down to the ground and coalesce into irregular trunks. This is why massive trees of kamahi, when felled, often prove to encase the remains of a tree fern on which they began life. Table A1, Appendix 1, lists the species that are likely to be seen in the tall forests of the lower hills and slopes.

Many plants of the lowlands and lower slopes do not ascend above 500 to 600 m. These include rimu, miro, tree ferns, and lianes other than bush lawyer. The upper montane forest (Fig. 11-13) is dominated by rata, kamahi, Hall's totara, and, at the highest altitudes, kaikawaka (*Libocedrus bidwillii*). Small trees and shrubs include broadleaf, *Pseudopanax simplex* which shows far-from-simple metamorphoses in leaf form as it grows from seedling to adult, and horopito (*Pseudowintera colorata*), easily recognised by the red and purple blotches on its hot-tasting leaves. Small-leaved divaricating shrubs include *Coprosma wallii*, *C. astonii*, and *Myrsine divaricata*. The commonest ferns are the shield fern *Polystichum vestitum*, which has short trunks with crowns of very dark green, somewhat prickly fronds, the mountain form of *Blechnum capense*, and a relative of the tree ferns, *Cyathea colensoi*, that has prostrate "trunks" lying just beneath the soil surface. *Astelia nervosa*, a lily with tufts of long, channelled leaves clad in silvery hairs, is also common. A moss with the forbidding name of *Dendroligotrichum dendroides* covers areas of forest floor with erect stems, up to 10 cm tall, that spring from a rhizome lying 15 cm below the surface. Species of the taller upland forests are listed in Table A2.

Through most of Westland, tall trees do not ascend higher than 900 to 1000 m where the forest is replaced by the vegetation known as subalpine scrub. This is formed by small trees and tall shrubs, most of which have thick, gnarled trunks, interlocking

branches, and dense, merging canopies (Fig. 15). The main species are leatherwood (*Olearia colensoi*, Fig. 14) which has finely serrate, leathery leaves which are cottony below and dark green and glossy above; *O. lacunosa*, a larger tree-daisy with narrow leaves, the margins of which are usually curled under so that there is a distinct channel between the edges of the leaf and the prominent midrib; *Senecio bennettii* with oval, smooth-margined leaves also glossy above and cottony below; inaka (*Dracophyllum longifolium*, Fig. 13) which has stiff, grass-like leaves and flowers borne in racemes; and *D. traversii*, a much larger tree-heath which has long, naked branches bearing tufts of long leaves surrounding a central inflorescence. The undergrowth is usually sparse, and the main species are *Blechnum capense* and *Astelia nervosa*. Where the soil mantle is somewhat unstable, as in the heads of gullies, mountain ribbonwood (*Hoheria glabrata*) is dominant. With soft, heart-shaped, winter-deciduous leaves and delicate, white flowers, ribbonwood groves contrast greatly with the prevailing dark, evergreen vegetation. Their undergrowth, where it has not been destroyed by deer, consists mainly of shield fern. Table A3 lists species of the subalpine scrub.

The sequence of forest belts so far described is found through most of Westland and also in some other areas, especially Mt. Egmont and Stewart Island. Elsewhere, lowland forest of podocarps and broad-leaved trees gives way in the montane belt to forest of beech (*Nothofagus*). At mid altitudes the beech trees are usually accompanied by other kinds of tree, especially where there is plenty of rain. Subalpine beech forest, however, usually consists of pure stands of a single species, and in South Westland this is silver beech (*N. menziesii*, Fig. 13) which forms sombre, often moss-shrouded forest. Patches of silver beech forest occur in the head of the Karangarua River, and from the Fettes Glacier in the Landsborough Valley it extends southwards with scarcely a break to Foveaux Strait.

The extreme upper limit of trees and tall shrubs, be they beeches or dominants of the subalpine scrub, is about 1150 to 1200 m. This is an important biological boundary which demarcates the subalpine belt from the alpine belt. The tree limit is correlated with summer warmth, and, for beech at least, the critical factor is whether the growing season is long enough for shoots to complete their annual cycle of growth so that they are fully dormant and hardened against the winter cold that follows. In beech forest areas, tree limit is apt to be a remarkably regular line across the mountain sides, so that one can speak of a distinct timberline (Fig. 37). The upper limits of subalpine scrub are much less even, for tongues of alpine grassland dip down into the subalpine belt, while tongues of scrub, formed by low-growing species, extend up into the alpine belt.

The low-alpine belt (Fig. 42, 46-49) is the region of tall grassland of snow-tussocks (*Chionochloa*, mainly *C. pallens*), although in remote valleys where herds of deer, thar, and chamois multiplied with little disturbance from hunters, snow-tussock has been replaced by browsed swards (see Chapter 7). Originally, the grassland contained an abundance of the giant, white-flowered buttercup known as "Mount Cook lily" (*Ranunculus lyallii*) and the carrot-like *Anisotome haastii*. The various species of mountain daisy (*Celmisia*) are still abundant, and some kinds have probably increased. The little speargrass *Aciphylla crenulata* is also common, although other species, such as *Aciphylla horrida* with its forbidding bayonet-like leaves, may be less common

than formerly. Seepages are occupied by a leafless sedge (*Schoenus pauciflorus*), with wiry, rush-like stems. On steep, rocky slopes and spurs, especially of northerly and westerly aspect, there is the low scrub already mentioned. It consists largely of the turpentine shrub *Dracophyllum uniflorum* (Fig. 13), which has also been destroyed over large areas. Table A4 lists species of these low-alpine communities.

Tall grasses and low shrubs largely cease about 1400 m although they cling to very steep, north-facing slopes to as high as 1950 m. In the first 200 m or so of the high-alpine belt (Fig. 50-51), there are short meadows of *Chionochloa oreophila*, *Poa colensoi*, and associated herbs. Most of the high-alpine belt comprises rocky or stony wastes with only scattered plants, for the duration of snow, the brevity and coolness of the growing season, and the disturbance of the soil by frost action are such that vegetation does not develop. Above the high-alpine zone there is the nival zone where the greater part of the terrain is covered by permanent snow and ice. In Westland National Park, the nival zone begins about 2000 m, but it must be stressed that vegetation boundaries above tree limit are exceedingly irregular; permanent snow occurs as low as 1500 m, and conversely, a vascular plant, *Parahebe birleyi*, grows to at least 2150 m, and lichens occur on snow-free rocks to the highest altitudes. The aim of this section is to stress an underlying regularity due to the altitudinal decrease of temperature. The complexities will be discussed later.

The influence of frost

On still, clear nights, the ground cools by radiating the warmth received from the sun during the day back to the sky and in turn chills the lowest layers of the air. These become denser than the warmer air above and therefore begin to flow down slopes and settle on the floors of valleys. During winter in the Southern Alps, the extent of snow makes the chilling especially widespread and severe. The valley floors become intensely cold and are apt to be gripped by frosts that thaw only when unsettled weather restores the normal altitudinal decrease of air temperature. Cold mountain air also spills out across the Alpine Fault as brisk gorge winds and spreads over the piedmont valleys.

Settling of cold night air at low altitudes has a great influence on the distribution of plants. The restriction of warm temperate species in South Westland to coastal slopes and other relatively frost-free sites has already been noted. Some other species are common in the piedmont area, but occur only on the mid slopes in the mountain valleys, and they meet their up-valley limits long before the valley floors rise to intersect their altitudinal limit; examples in approximate order of their disappearance are kiekie and the small tree *Ascarina lucida* (Fig. 3), both of which scarcely enter these valleys, quintinia, red rata vine, pigeonwood, and soft tree fern. Even kamahi, which reaches 900 m on the outer slopes of the Alps, is virtually absent from valley heads against the Main Divide, where the forest is dominated at altitudes of only 550 to 750 m by rata, kaikawaka, Hall's totara, broadleaf, and mountain holly (*Olearia ilicifolia*, Fig. 14).

Silver beech has a wider range of temperature tolerance than most Westland trees and in the Landsborough Valley dominates the forest from 100 m above sea level up to tree limit. In the frosty upper reaches beyond Harper Bluff, other trees are rare and mostly confined to warm mid slopes where there are scattered kamahi, Hall's totara, and pokaka (*Elaeocarpus hookerianus*, Fig. 4) among the beech. Even beech gives way to grassland on the wider valley flats. While soil conditions play a part in this pattern, frost is undoubtedly the main factor acting against the trees. Grassy valley flats occur also in the tributaries of the Karangarua River, north of the limit of silver beech (Fig. 39).

Chilling by ice and snow is still more intense in the valley heads occupied by glaciers; to enter the glacial reaches of the valleys is to return to the ice age. Even where glaciers descend to unusually low altitudes, as in the cases of the Franz Josef, Fox, and Balfour Glaciers, the slopes above the ice support discontinuous grass and low scrub rather than forest, although this results more from glacial oversteepening and instability of the valley sides than from climate. The renowned juxtaposition of glacier and tree ferns at Franz Josef Glacier was, in so far as it was more than skilful angling of the camera, the result of recent advance of the glacier into lowland vegetation (see Chapter 5).

While many species have their up-valley limits set by cold valley-floor temperatures, others characteristic of high altitudes extend downwards on to frosty sites. The valley grasslands are a case in point; many, though not all, of their species thrive also in the alpine belt. For example, in grassy openings at 210 m in the Waiho Valley, the dominant native grass is *Poa cockayniana* (Fig. 49) which has a very wide altitudinal range, but the typically low-alpine species *Celmisia coriacea* (Fig. 47) also occurs there. Kaikawaka, mountain holly, and *Cyathea colensoi* (Fig. 11), all common plants in the upper part of the montane belt, are conspicuous on valley flats in the mountains and grow even on lowland flats beside the Tatare Stream, where the Waiho loop moraine hinders the escape of cold air down the lower reaches of the Waiho Valley. Kaikawaka and leatherwood also border the frosty flat where the main highway crosses the Omoeroa River.

Rain, cloud, and humidity

Water exists in solid, liquid, and gaseous states in the environment, and each state influences the distribution of vegetation. The liquid state is the most important in the life of plants, but, as South Westland has a renowned superabundance of rain, there are rarely times when the soil cannot supply enough water for their needs, even when small streams dry up and livestock suffer from shortage of water. By the same token, most plant communities in South Westland are not differentiated according to availability of moisture as is commonly the case in drier districts, despite a gradient in rainfall from about 3500 mm annually at the coast to 5000 mm at the foot of the ranges. Among the outer ranges, it probably reaches 10 000 mm. Ability to withstand drought is important mainly on very stony sites such as moraines, where

soil particles are too coarse to hold water within the rooting zone of plants. For this reason, vegetation can take many decades to cover such material, even in the lowland belt. Shortage of unfrozen water is a factor in the distribution of plants at very high altitudes, where some of the highest stations for vascular plants are moist, north-facing fissures.

Epiphytes intercept moisture before it reaches the ground, and in this rainy climate they are abundant in the forest. Filmy ferns and many of the mosses shrivel to air dryness during rainless periods but become green again when moistened. Death and decay of these small plants forms humus on trunks and logs in which larger plants take root. These include seedlings of important trees, and other plants which remain as epiphytes, for example the shrubby puka, the orchids *Earina autumnalis*, *E. mucronata*, and *Dendrobium cunninghamii*, and the ferns *Asplenium falcatum* and *A. flaccidum* (Fig. 10). While these species do not have any obvious adaptations to their epiphytic habitat, two species which grow on exposed branchlets near the top of the forest canopy are more obviously adapted to a precarious water supply. The tiny orchid *Bulbophyllum pygmaeum* has swollen, bulb-like bases to its leaves, and the creeping fern *Pyrrosia serpens* has thick, fleshy, undivided fronds. Other epiphytes, including lanternberry (*Luzuriaga parviflora*) and some filmy ferns and bryophytes, evade severe drought by tolerating deep shade at the bases of tree trunks.

Gaseous water occurs as atmospheric humidity. The less humid the air, the greater is its drying power, and the latter is increased by movement of the air. When humid air is cooled, it reaches dew point, i.e., the temperature at which the vapour condenses into droplets of liquid water to give mist or cloud which may thicken to rain. Gradients in air humidity, air movement, and frequency of cloud contribute to the variation in plant cover. Near the coast, there are sea breezes during fine weather, and trees bear a rather sparse cover of epiphytes. Along the foot of the main ranges and in the lower reaches of the mountain valleys, on the other hand, the air is normally calm, and even during settled weather sunlight is diminished by afternoon cloud and drizzle. Epiphytes, especially bryophytes and filmy ferns, have their richest development under these conditions and nowhere more than on cool valley floors subject to morning mists, where even canopy twigs are draped with the pendent moss *Weymouthia* (Fig. 9).

The afternoon cloud belt forms against the ranges at around 700 to 1800 m. Here, fog condenses on foliage and augments the high precipitation. Windiness and cool temperatures preclude any striking growth of epiphytes, and the main ecological effect of the persistent cloud may be to reduce the amount of sunlight that reaches the plants. Leatherwood (*Olearia colensoi*) is strongly associated with the cloud belt, dominating extensive tracts at subalpine levels in the outer ranges. Elsewhere it is quite rare, being largely confined to cold, damp hollows at low altitudes and to steep, shaded, wet cliffs in the subalpine belt of the inner ranges where the cloud cover is thinner, less frequent, and forms later in the afternoon. Under these sunnier conditions of the inner ranges, other plants occur which are not found further west, notably snow totara (*Podocarpus nivalis*, Fig. 13) which is abundant on rocky spurs and on some moraines in the subalpine and low-alpine belts.

The change to a more drought-tolerant vegetation on the eastern side of the Main Divide is perhaps the most impressive aspect of South Island plant geography. In part this reflects lower rainfall, but the change is already obvious enough in the heads of the eastern valleys, such as those in Mount Cook National Park where the rainfall still exceeds 4000 mm. This is because of reduced humidity which is especially low when the dry north-west wind blows. The prevailing westerlies lose most of their moisture as rain and cloud and gain latent heat in rising up the western slopes and valleys, and in descending as a typical föhn, they gain further heat during compression; as the wind becomes warmer, its evaporative power increases. When an easterly storm rages on the Canterbury side of the Alps, a reverse föhn can blow down the Westland valleys, but this only happens two or three times a year and usually only for a few hours at a time.

Though the vegetation west of the Main Divide is so lush, it has to be conceded that, area for area, there tend to be more kinds of native and introduced plants in the open landscapes that prevail to the east. Drought-tolerant plants thrive, such as the spiny matagouri (*Discaria toumatou*) and thick-stemmed native brooms (e.g., *Carmichaelia petriei*). Habitats such as flood plains, slips, burn scars, and rock bluffs take longer to develop a cover of dense vegetation, so they support a greater variety of plants that need space and light. One may compare 8 species of *Hebe* in and near Westland National Park with 14 species listed by H.D. Wilson for the much smaller Mount Cook National Park which does not extend below 600 m. Six species of *Raoulia* and 5 of *Senecio* in Westland National Park may also be compared with 10 of each in Mount Cook. At the same time there are sites in the eastern regions, such as moist gullies, that support many of the moisture-demanding species characteristic of the west.

Snow and ice

Snow falls so rarely on the Westland lowlands that it is of no ecological significance at all, and although moderately severe frosts occur in the valleys, it is the low temperature, and not the hoar-frost, that is likely to damage plants. In the mountains, on the other hand, snow and ice are major architects of the landscape and vegetation. In the nival belt, especially in depressions and gullies with southern to eastern aspect, snow lies the year round and accumulates to become compacted into névé — the ice that feeds the glaciers. Steep slopes of northerly aspect, however, are bare of snow much of the time and support lichens where frost-riving is not too active.

In the high-alpine belt (Fig. 50-51), duration of snow cover is the major single factor affecting the distribution of plants. At one extreme, there are steep, northerly slopes free of snow all summer and much of the winter, where continuous vegetation with snow-tussocks and small shrubs such as *Hebe ciliolata*, *H. treadwellii*, and *Dracophyllum kirkii* ascend to very high altitudes. At the other extreme are permanent snow patches which occupy deep, south-facing hollows where the snow falling on the spot is augmented by drifts or avalanches. Even in these places one can find plants, single-celled algae, which reveal their presence by the red colour they impart to the snow.

Where snow is absent for a few weeks, there are mats of green moss (species of *Brachythecium*, *Bryum*, and *Bartramia*). A few snow-tolerant species of vascular plants appear where snow disappears between late January and mid February, especially the mat plant *Raoulia subulata*, the sedge *Carex pyrenaica*, and the buttercup *Ranunculus sericophyllus*. The last has often already opened its bright yellow flowers before it emerges from the snow and has exact ecological counterparts in *Ranunculus glacialis* of the Eurasian mountains and *R. adoneus* of the North American Rockies.

Continuous high-alpine vegetation begins on stable ground where snow disappears before New Year. Where soils are fine-textured, there is short, turfy grassland of *Poa colensoi* and *Chionochloa oreophila*, accompanied in steeper places by tufts of the alpine rush, *Marsippospermum gracile*. On stony slopes these share dominance with mat plants such as *Celmisia sessiliflora*, *Drapetes lyallii*, *Coprosma pumila*, *Raoulia grandiflora*, and *Anisotome flexuosa*, while on the more exposed ridges and spurs there is discontinuous vegetation dominated by cushion plants including *Colobanthus monticola*, *Luzula pumila*, *Hectorella caespitosa*, *Anisotome imbricata*, *Phyllachne colensoi*, and *Pygmea ciliolata*. The vegetable sheep or woody raoulias, which are distinctive members of corresponding cushion vegetation east of the Southern Alps, are nearly absent from Westland National Park.

Over large expanses of the alpine zone, the short growing season, steepness, the abundance of moisture after snow-melt, and above all, repeated freeze and thaw, combine to make for expanses of unstable, broken rock almost devoid of plants. Yet, a few species have their chief habitats among such talus, growing where the rocks are less mobile or the talus material finer and more retentive of moisture. Examples are the grass *Poa novae-zelandiae*, the willow-herb *Epilobium glabellum*, *Claytonia australasica* (all of which occur almost to sea level in suitable habitats), *Schizeilema haastii* with round, glossy bright-green leaves up to 2.5 cm across, and several forget-me-nots (*Myosotis*). Two beautiful buttercups which become very rare where browsing mammals are common also grow mainly on talus: the yellow-flowered *Ranunculus godleyanus* in the north of the park and the white-flowered *R. buchananii* in the south. The distribution of species through the main high-alpine habitats is shown in Table A5.

Snow lies through the winter months, i.e., from about June to September or October, over most of the low-alpine zone, but differences in duration of snow cover are probably not as ecologically important here as differences in other environmental factors. Snow cover is still less important in the subalpine belt, where it usually lasts only a few weeks at a time. In both belts, however, destruction by snow avalanching from high altitudes is very important. The effect is very striking in the Landsborough Valley where continuity of the subalpine beech forests is broken by great avalanche tracks occupied only by herbaceous vegetation or low, springy shrubs such as snow totara, mountain wineberry (*Aristotelia fruticosa*, Fig. 12), and *Coprosma ciliata*. Avalanches are equally severe in other mountain valleys and cut broad swaths in which vegetation never attains maturity. In the Karangarua and Copland Valleys especially, there are permanent avalanche tracks which terminate in the valley floors only 200 to 300 m above sea level.

Wind

New Zealand lies across the windiest latitudes in the world, and vegetation can show the influence of extreme exposure to wind, perhaps nowhere more than in the vicinities of Cook and Foveaux Straits where the westerlies are funnelled between the main islands. In Westland, however, the Southern Alps are a barrier against which a cushion of calm air is held. The westerly winds are forced aloft, to descend east of the Main Divide as the violently gusting "norwesters" described on p.17. Inland in South Westland, extreme wind-pruning of trees is rare, even on exposed ridges in the mountains. Along the coast, winds have more effect, for they are often laden with salt spray which is apt to "burn" exposed shoots. However, even here the influence of wind is slight and localised compared with other districts. Forest can occur immediately behind the storm beach, although in this habitat trees such as rimu often develop a canopy only on their landward side. Perhaps the most exposed stretch of coast is Okarito Spit; here are typical features of a windy coastline, including sand dunes and, in their lee, remnants of forest with leaning, gnarled trunks and dense, wind-shorn canopies.

Occasionally winds are violent enough to wreak extensive damage, breaking branches and uprooting trees. Such winds usually accompany frontal storms sweeping up along the Alps from the south-west, or gust violently out of the mountain valleys during easterly weather. Rarely, they come in from the sea bringing very heavy surf, and salt-burning of foliage can occur more than 1 km from the coast.

The light factor

Sunlight provides the energy for photosynthesis and the warmth that activates living processes. Four things influence the amount of light reaching plants: latitude, duration and density of cloud cover, aspect, and the presence of other overshadowing plants. Latitude, for South Westland, means that on midsummer's day the sun is only 20° from the zenith and, discounting shadowing by mountains, is above the horizon for 15 hours 20 minutes. In mid winter, there are only 9 hours between sunrise and sunset, and less than a quarter as much solar energy is received on a clear day. Contrary to popular prejudice, Westland has a sunny climate near the coast (1840 hours per annum at Hokitika), because the rain comes as heavy falls that are quickly followed by clear skies. Cloudiness increases markedly near the mountains, so that in the fog belt along the outer ranges sunlight may well be suboptimal for plant growth.

Aspect differences in vegetation are relatively minor in the forested lowlands, although the kiekie vine is noticeably more abundant on north aspects. By contrast, aspect has overriding importance in the high-alpine zone, although differences directly related to the amount of light and warmth impinging on plants are not readily distinguished from differences due to snow cover. At intermediate altitudes, northern aspects favour scrub on steep slopes in the low-alpine belt and the highest occurrences of rimu up-slope and up-valley in montane forest.

Competition among plants to obtain enough light for survival and growth is one of the main factors determining the composition of vegetation, except in habitats where only scattered plants occur, such as under harsh conditions in the high-alpine belt and on newly formed land surfaces, or where vegetation is very short as in salt meadow and high-alpine grassland. Even in snow-tussock grassland, competition for light is important for small plants and seedlings, and it is most intense in tall lowland forest where each storey experiences a different light environment, and the plants of the lowest must be adapted to survive and grow at light intensities which can be a fraction of 1 percent of full sunlight. In the forest, only the smallest plants experience fairly stable light conditions throughout their life cycles. The crowns of dominant trees receive plenty of light, but their seedlings and saplings do not enjoy this favoured position. The seedlings of some tree species evade the deep shade of the forest floor by adopting an epiphytic position, as described on p.12. Other species, including silver beech, germinate and survive for many years on the shaded forest floor, but gain little until a break appears in the canopy above them, when they will grow quickly up to the light. Podocarps such as rimu do not respond so rapidly to light, but they can grow slowly but steadily up through moderate shade — a rimu sapling commonly takes over 100 years to reach the canopy. However, seedlings of podocarps do not tolerate the deep shade under lush fern growth in gullies, and, largely for this reason, mature podocarp trees in hilly country tend to be concentrated on ridges and spurs. The seedlings of some trees require strong light, and these are not normally members of mature forest. However, when a large tree is blown over, so that a large pool of sunlight reaches the forest floor, light-demanding species such as wineberry (*Aristotelia serrata*), fuchsia (*Fuchsia excorticata*), and marble leaf (*Carpodetus serratus*) can become established (Fig. 19, 21). Lianes grow rapidly to the canopy by economising on the amount of wood they need to form.

In **plant successions**, i.e., the progressive development of vegetation on bare surfaces, light is an important factor. This is especially so in **secondary successions**, which ensue after vegetation is destroyed by agents, such as fire, which do not remove the soil. A common secondary succession follows burning of lowland forest. The first plants to appear on the site are usually mosses and liverworts followed by "fire weeds" including a tall groundsel (*Senecio minimus*, Fig. 21) and various willow-herbs (*Epilobium*). The first shrubs and trees are those which need much light for their growth, especially manuka (*Leptospermum scoparium*) on poor soils and wineberry on better soils. The species of the original forest re-establish in their shade, but it takes centuries for the forest to recover its original composition.

Fig. 2 **Habitat I.** This mainly shows plants typical of forest at the lowest altitudes. The central tree fern is *Cyathea smithii*, distinguishable by its skirt of dead fronds. *Dicksonia squarrosa* stands behind it. The orchid *Dendrobium cunninghamii* perches at middle-left. Three lianes are illustrated: the rata vine *Metrosideros perforata* at left, canes of supplejack (*Ripogonum scandens*) in the foreground, and the long, narrow leaves of kiekie (*Freycinetia banksii*) at right. Foliage of the small tree *Ascarina lucida* is in the right foreground.

a x 1/2

(i)

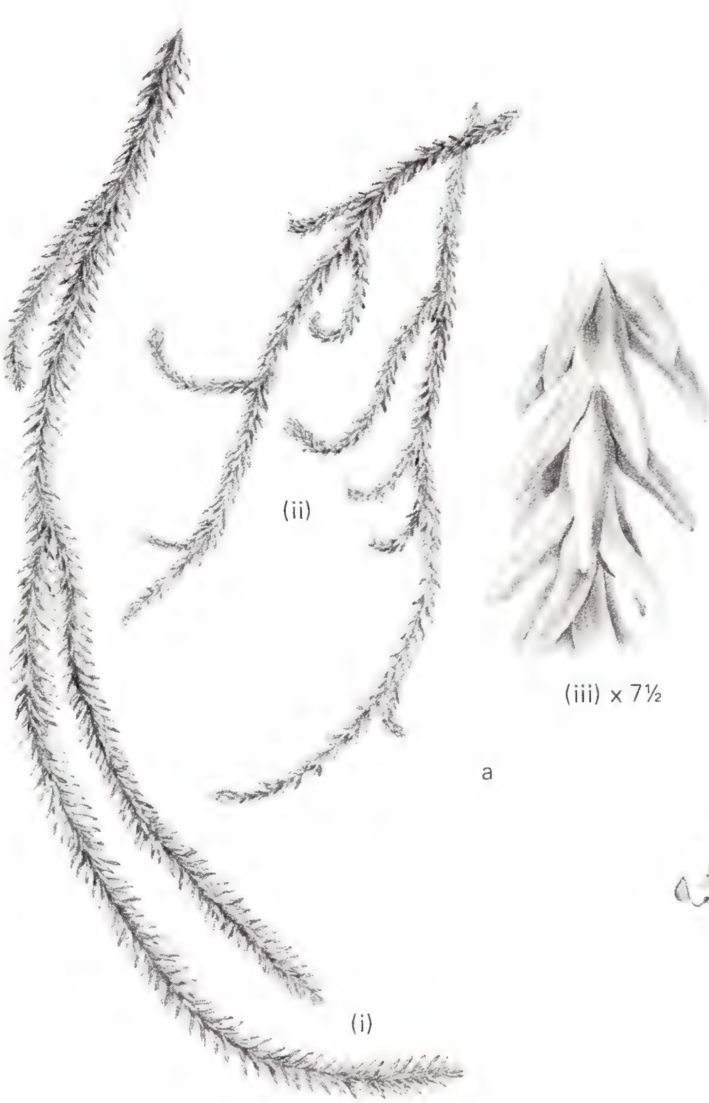
(ii) x 5

b x 1/2

Fig. 3
Forest plants
a. puka (*Griselinia lucida*) x 1/2;
b. broadleaf (*Griselinia littoralis*) x 1/2, (i) fruit (ii) flower x 5;
c. *Ascarina lucida* with fruits, (i) fruit x 10.

a

Fig. 4
Forest plants ctd.
a. hinau (*Elaeocarpus dentatus*) adult leaves and flower buds, (i) juvenile leaf;
b. pokaka (*Elaeocarpus hookerianus*), (i) adult and (ii) juvenile leaves.



a

d

c x 1/2

Fig. 5
Forest plants ctd.
a. rimu (*Dacrydium cupressinum*), (i) juvenile and (ii) adult foliage, (iii) detail of (ii) x 7½;
b. *Quintinia acutifolia*;
c. toro (*Myrsine salicina*) x 1/2;
d. matipo (*Myrsine australis*);
e. pigeonwood (*Hedycarya arborea*) x 1/2, (i) fruit.

a x 1/4

(i) x 1/2

c x 1/2

b x 1/3

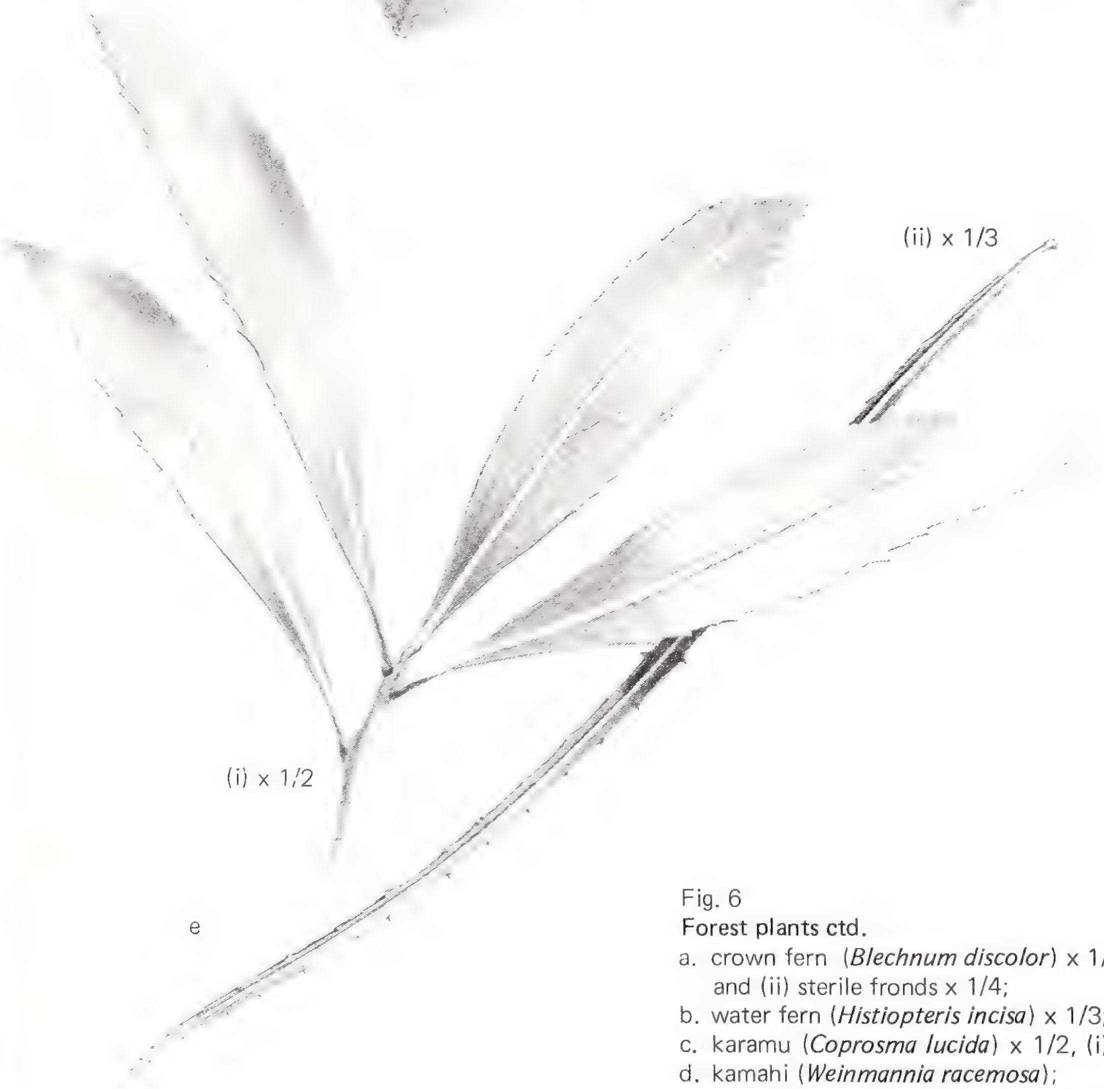


Fig. 6
Forest plants ctd.

a. crown fern (*Blechnum discolor*) x 1/4, (i) fertile and (ii) sterile fronds x 1/4;
b. water fern (*Histiopteris incisa*) x 1/3;
c. karamu (*Coprosma lucida*) x 1/2, (i) fruit x 1/2;
d. kamahi (*Weinmannia racemosa*);
e. lancewood (*Pseudopanax crassifolius*), (i) adult leaves x 1/2 and (ii) juvenile leaf x 1/3.

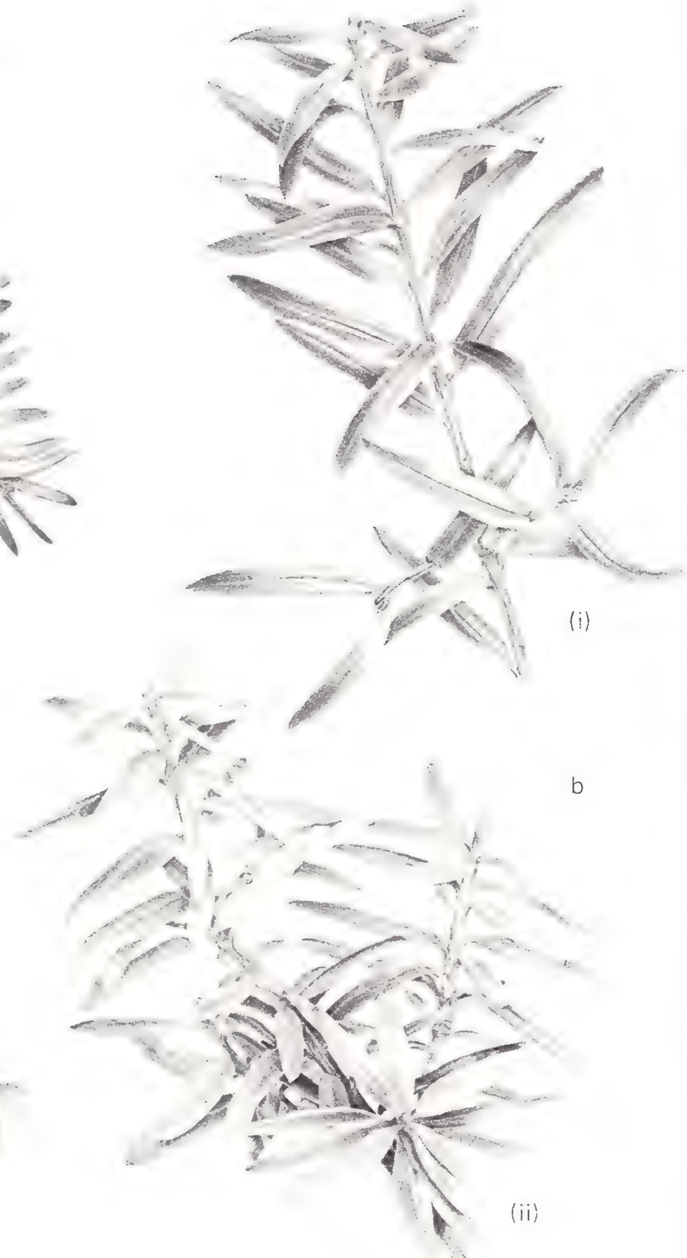


Fig. 7
Forest plants ctd.
a. miro (*Podocarpus ferrugineus*);
b. Hall's totara (*Podocarpus hallii*), (i) juvenile and (ii) adult foliage;
c. *Nertera* cf. *dichondraefolia*, (i) fruit x 2.

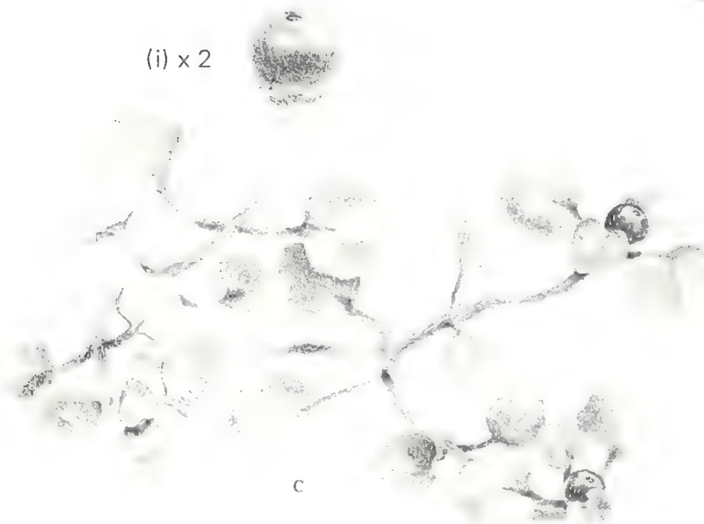
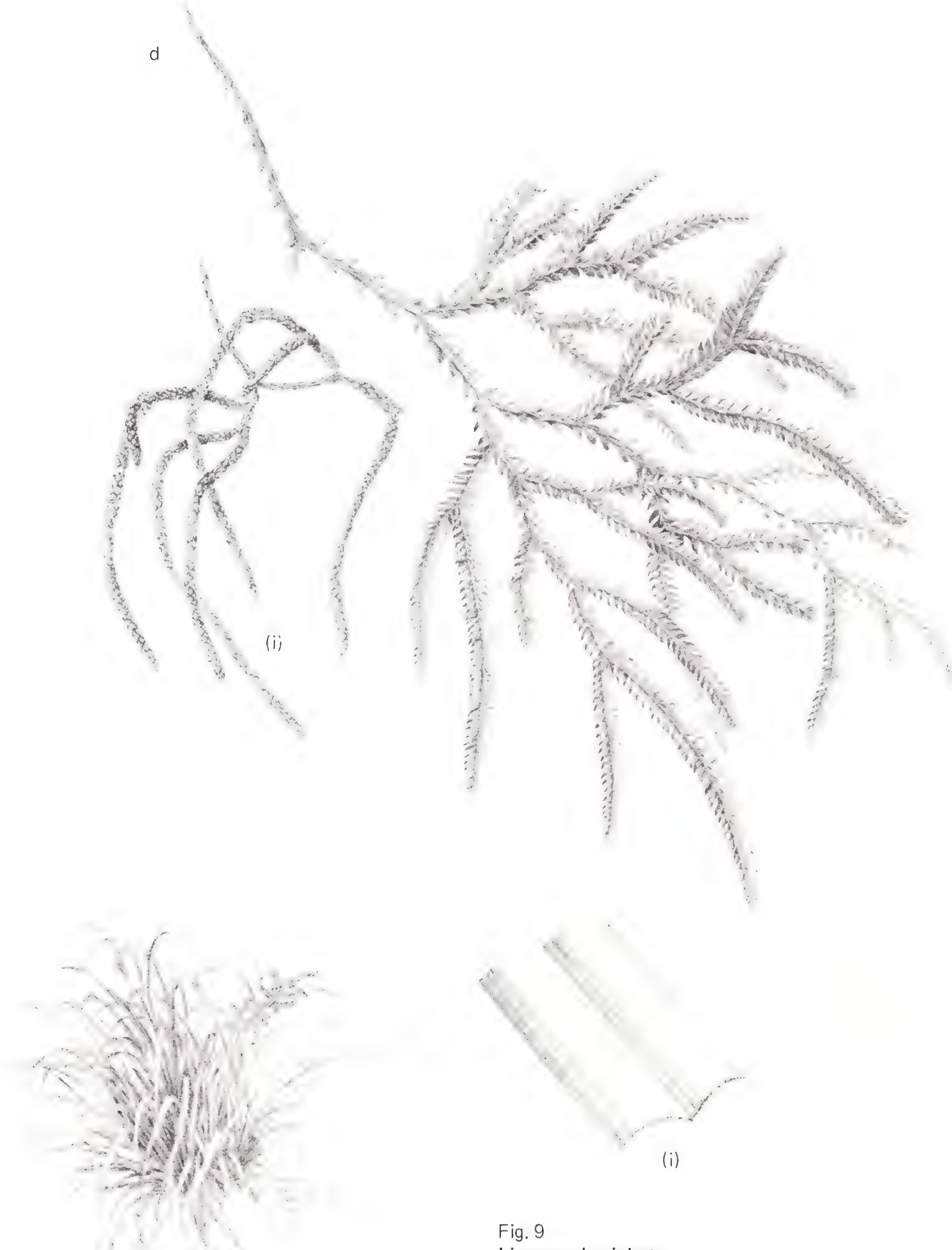


Fig. 8 Opposite

Habitat II. Species typical of the lower montane forest are illustrated. At the top left and top right respectively, there are the trunks and foliage of rimu (*Dacrydium cupressinum*) and kamahi (*Weinmannia racemosa*). The rimu trunk supports two kinds of the root climbing rata vines (*Metrosideros perforata*, and to its right *M. fulgens*), a tuft of *Astelia solandri*, and the epiphytic fern *Asplenium falcatum*. Of the shrubs and smaller trees, *Coprosma lucida* is shown on the left, and the crinkled leaves of *Quintinia acutifolia* at centre.

From left to right in the immediate foreground, there are the giant moss *Dawsonia superba*, the filmy fern *Hymenophyllum demissum*, the lichen *Pseudocyphellaria impressa*, and the broad fronds of *Phymatodes diversifolium*. Behind these, are tufts of crown fern (*Blechnum discolor*, at left), kidney fern (*Trichomanes reniforme*, centre), and the moss *Ptychomnion aciculare* (right).


b
a
(i) x 2
c x 1/2
(i) x 6



e x 1/20

Fig. 9
Lianes and epiphytes
a. *Pyrrosia serpens*;
b. *Tmesipteris tannensis*, (i) fertile leaf x 2;
c. *Weymouthia mollis* x 1/2, (i) detail of foliage and spore capsule x 6;
d. *Lycopodium volubile* (i) "cones";
e. *Astelia solandri* x 1/20, (i) section of leaf.


a x 1/3
(i)
b
(i) x 8
c

Fig. 10
Lianes and epiphytes ctd.
a. *Asplenium flaccidum* x 1/3, (i) sorus x 8;
b. red-flowered rata vine (*Metrosideros fulgens*), (i) flower;
c. *Earina autumnalis*;
d. bush lawyer (*Rubus cissoides*);
e. lanternberry (*Luzuriaga parviflora*).

Fig. 11 **Habitat III.** Upper montane forest on the track to Alex Knob. The dominant trees are the conifer *Libocedrus bidwillii* or kaikawaka, and southern rata (*Metrosideros umbellata*) with its rounded, billowing canopy. In the foreground, attention is drawn, from left to right, to bush rice-grass (*Microlaena avenacea*), a sapling of the ivy tree *Pseudopanax simplex*, a frond of *Cyathea colensoi*, the weak-stemmed *Coprosma depressa*, and a giant moss, *Dendroligotrichum dendroides*.

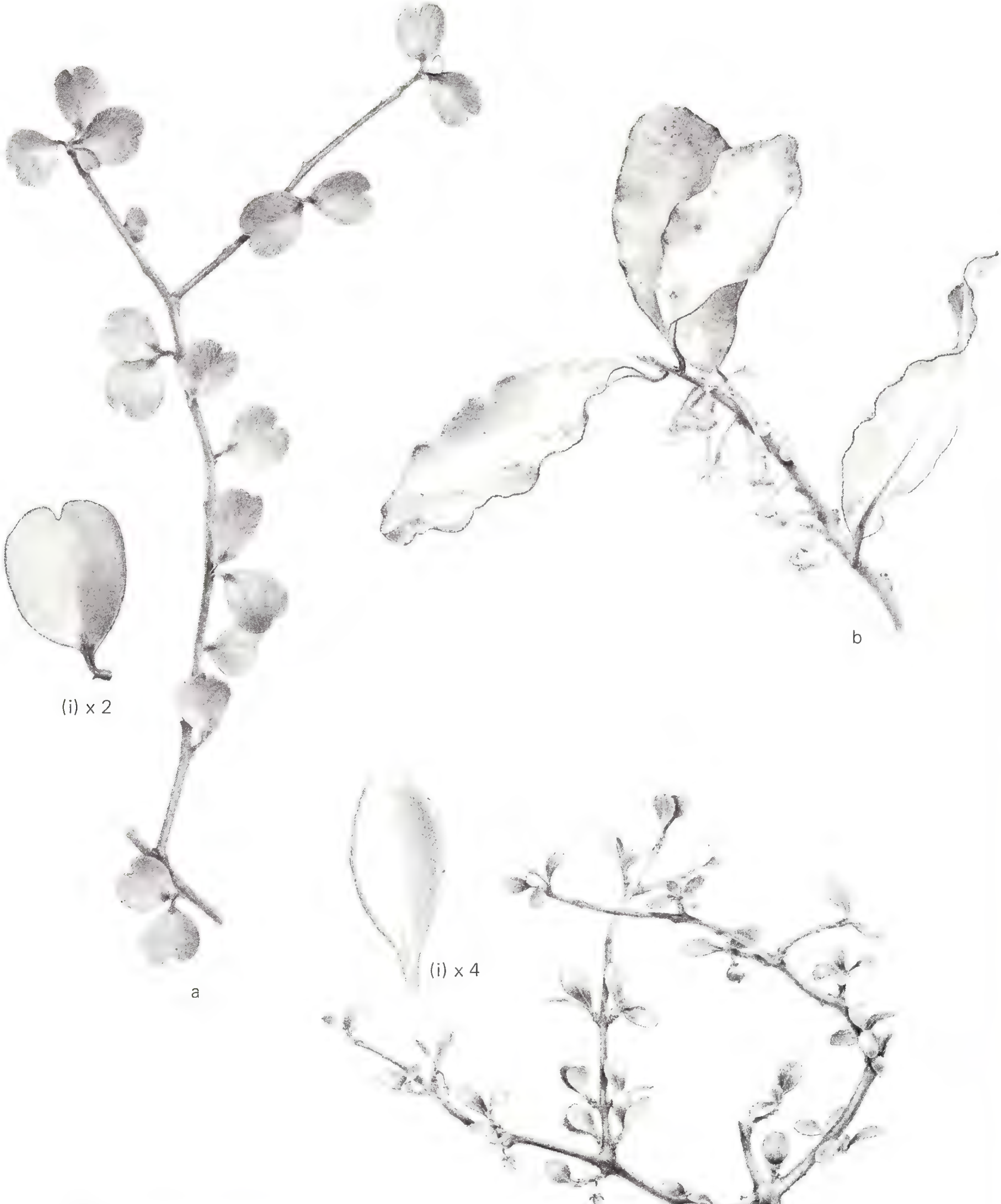


Fig. 12
Plants of upper montane forest
a. *Myrsine divaricata*, (i) leaf x 2;
b. horopito (*Pseudowintera colorata*);
c. *Aristotelia fruticosa*, (i) leaf x 4;
d. *Pseudopanax simplex*, adult foliage, (i) juvenile leaf;
e. three-finger (*Pseudopanax colensoi* var. *ternatus*) x 1/2, (i) stipule.

(i)

d

(i)

e x 1/2

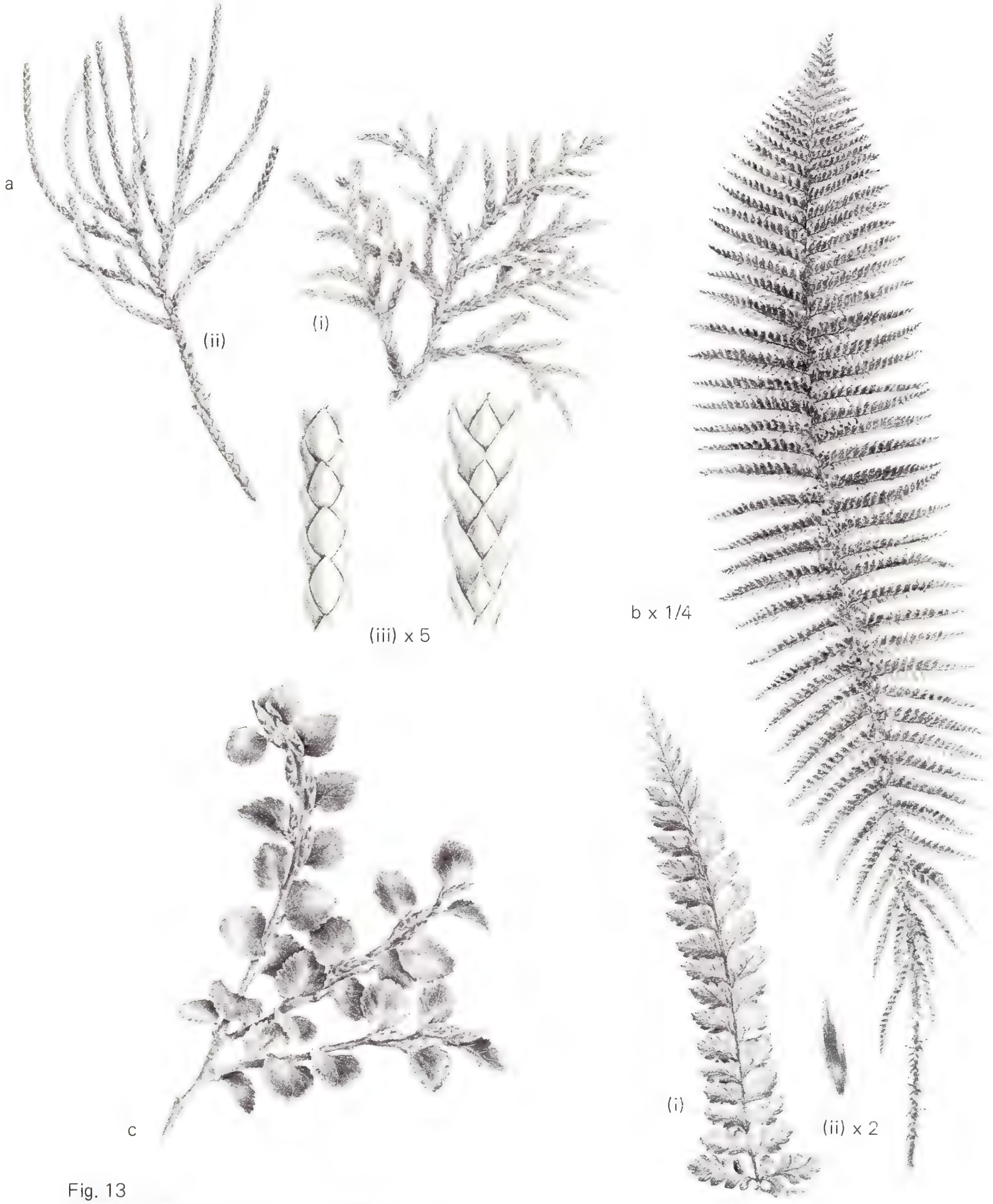
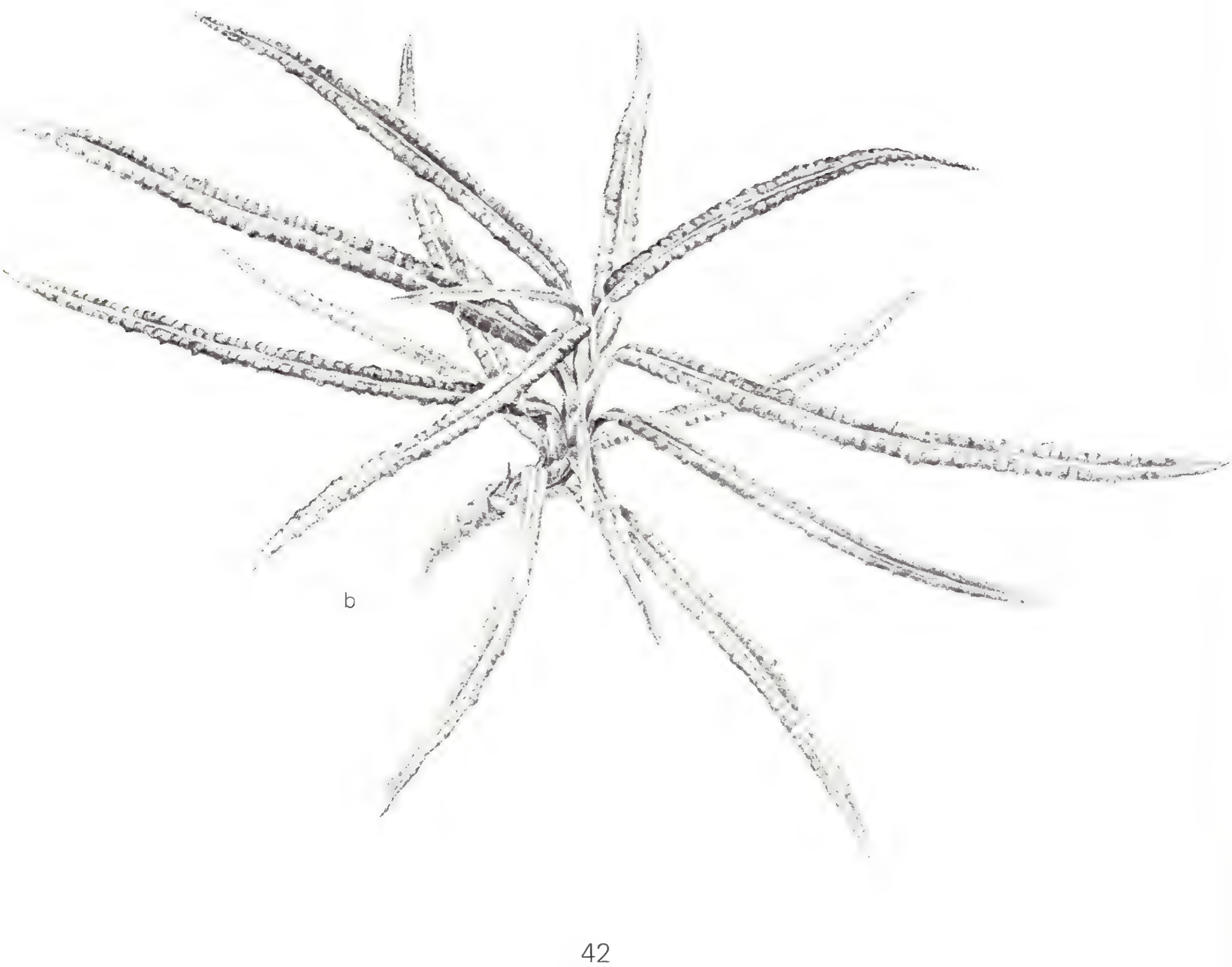


Fig. 13
Plants of high-altitude forest and subalpine scrub
a. kaikawaka (*Libocedrus bidwillii*), (i) juvenile and (ii) adult foliage, (iii) detail of (i) and (ii) x 5;
b. shield-fern (*Polystichum vestitum*) frond x 1/4, (i) details of frond, (ii) scale x 2;
c. silver beech (*Nothofagus menziesii*);
d. a form of *Blechnum capense*, (i) fertile and (ii) sterile fronds x 2/3;
e. inaka (*Dracophyllum longifolium*);
f. turpentine shrub (*Dracophyllum uniflorum*);
g. snow totara (*Podocarpus nivalis*), (i-iii) details of leaves, fruit x 2, catkin.


e
f
(iii)
(ii) x 2
(i)
(ii)
d x 2/3
(i) x 2
g

Fig. 14
Species of *Olearia*
a. *O. moschata*;
b. *O. lacunosa*;
c. leatherwood (*O. colensoi*);
d. mountain holly (*O. ilicifolia*).

a



b

c

d

Fig. 15 **Habitat IV.** Dense, tall, subalpine scrub, such as that at 1000 m on Alex Knob, includes a considerable variety of woody plants. The foreground shows the leaves of three-finger (*Pseudopanax colensoi*), each divided into three leaflets, and to the right, leatherwood (*Olearia colensoi*). Three species of *Dracophyllum* are illustrated; at the left and to the right of centre, the tall, narrow-leaved *D. longifolium* or inaka; behind this, and also on the

extreme right, the unbranched stems and large leaf tufts of *D. fiordense*; dominating the right middle-distance, the candelabra-like *D. traversii*. The narrow-leaved shrub in the centre of the plate is *Olearia lacunosa*. The tussocky herb *Astelia nervosa* and the fern *Blechnum capense* are also shown.

2

Soil and succession

The factors of soil formation

After altitudinal differences in temperature, soil is the next most important cause of variations of the plant cover of Westland, excepting at very high altitudes where aspect and duration of snow cover are more effective. Differences in soils which are important to plants are the different abundances of chemical substances which promote or inhibit plant growth; the variations in water content at different seasons and depths; the depth of soil available for roots to find a firm hold, nutrients, and water; and the composition of the atmosphere between soil particles, there being a range from free-draining soils with abundant oxygen, which promotes healthy growth of roots, to puggy soils that are saturated with slow-moving water and have excess carbon dioxide and other more toxic gases such as hydrogen sulphide.

These differences arise in five ways. First, there is the nature of the material from which the soil is forming. In Westland National Park, the parent materials are, almost without exception, schist, greywacke, and granite and the moraine, river gravel, sand, and silt derived by erosion from these rocks. Chemically, they all consist mainly of silica and do not give rise to such fertile soils as those derived from limestone and basalt which contain more calcium, potassium, and phosphorus, elements important in the nutrition of plants. Ultrabasic rocks, which have toxic amounts of magnesium and various heavy metals and therefore give rise to very infertile soils, are also absent from the park, although they outcrop as the Red Hills in the far south of Westland. The differences in parent material in the region, therefore, are mainly physical differences; the extremes are provided by solid bedrock scraped bare by glaciers and deep silty sand, coarse enough to be freely drained and well aerated while fine enough to retain sufficient moisture between the particles to prevent drought.

The second cause of soil differences is the climate in which they develop. This includes temperature, for the soil-forming processes are more rapid in warmer temperatures. Rainfall in excess promotes water-logging of poorly drained soils, while in well-drained soils soluble plant nutrients, notably ions of calcium, potassium, nitrogen, and phosphorus, are leached downwards beyond the reach of roots. Westland soils therefore tend to be deficient in these important substances, in contrast to dry regions such as Central Otago where salts can reach toxic concentration.

Topography is also an environmental factor in that slope and configuration of the surface affect drainage and movement of the soil. The steeper the slope, the more

rapid the downward movement of the soil mantle; it can vary from catastrophic landslides that re-expose parent rock to gradual downhill creeping and mixing of the soil without disruption of the vegetation.

Vegetation is the fourth major determinant of soil properties, although dependent itself on the soil and other features of the environment. Plants contribute to soil composition in various ways — their roots enter fissures in rocks and hasten their fragmentation into soil; they protect the surface from frost and water, thereby holding the soil mantle in place; and most important, they supply organic matter to the soil as surface litter of fallen leaves and twigs and also as decaying roots. The litter breaks down into humus which can be classified either as **mor** or **mull**, to use two terms introduced by Danish soil scientists. Mull humus is richer in plant and animal nutrients than mor humus, it is attacked more vigorously by the organisms of decay including insect larvae, millepedes, earthworms, fungi, and bacteria, and it tends to be carried down by the invertebrates into the mineral soil. Here it forms loose physical and chemical unions with the soil particles, which aggregate into the crumb- or nut-like fragments characteristic of many fertile soils. Mor humus, on the other hand, is less nutritious and tends to accumulate as a fibrous blanket over the mineral soil. Mull-forming plants such as mahoe (*Melicytus ramiflorus*, Fig. 22) and the deciduous lowland ribbonwood (*Plagianthus betulinus*, Fig. 29) require high quantities of nutrients so they tend to occur on the richer soils, and mor-forming plants such as rimu (*Dacrydium cupressinum*) and silver beech (*Nothofagus menziesii*) tend to occur on poorer soils. Nevertheless, in time species imprint their own characteristics on the soil, and under trees such as kauri (*Agathis australis*), rimu, beeches, or the introduced *Pinus radiata* even initially fertile soil will eventually deteriorate. Organic matter accumulates as peat where conditions are particularly unfavourable for decay of humus, for instance, beneath stagnant water, on soil saturated to the surface, and in coastal areas in the far south of New Zealand with cool, cloudy, windy climates.

The fifth way in which soil differences arise has to do with time. At first, fertility increases, one reason being that soluble compounds of nitrogen are added to the soil. To a small extent these are brought in by rain, but chiefly they increase through the activity of microbes that "fix" nitrogen, i.e., extract gaseous nitrogen from the atmosphere and incorporate it into organic compounds. Some of these microbes are free-living in the soil, but others live in close union or symbiosis with higher plants, exchanging some of the nitrogen which they have fixed for sugars produced by their hosts. In Westland, the host plants are the legumes, including the native brooms (*Carmichaelia*) and kowhai (*Sophora microphylla*) and the introduced clovers (*Trifolium*), *Lotus*, and gorse (*Ulex europaeus*), which have nitrogen-fixing bacteria in small nodules on their roots; the species of tutu (*Coriaria*) which have root nodules in which the nitrogen-fixing organisms appear to be fungi known as actinomycetes; and the species of *Gunnera* which have nitrogen-fixing algae living in cavities at the bases of their leaf stalks. By and large, these plants grow on recently formed soils. A second reason for the initial increase of soil fertility is that as the rock fragments weather, soluble compounds of phosphorus and other elements become available to plants.

After 1000 years or so, under Westland climate and vegetation, fertility begins to decline on freely drained parent material such as river gravel, talus, or moraine. Mull-forming species become replaced by mor-formers, and percolating water charged with mild acids derived from mor humus leaches the weathering rock particles of the upper mineral layer which is known to soil scientists as the **A horizon**. In this way nutrients, fine particles of humus, and the oxides of iron and aluminium are washed downwards. The iron oxide and some of the organic matter are precipitated at depths of 10 to 50 cm; the resulting **B horizon** is distinguishable by rusty or dark brown colorations due to iron and humus respectively. Below the B horizon is the C, or weathering parent material. Where this ABC profile becomes well developed, the soil is called a podzol.

Under silver beech forest, gravelly soils can become visibly, though weakly, podzolised in less than 500 years. Usually, however, release of iron oxides through weathering gives rise to a B horizon 25 to 60 cm thick, with an overall yellow-brown colour which at first obscures the evidence for substances being washed in from the A horizon. Under lowland forest, such **podzolised yellow-brown earths** can become well developed within 5000 years.

Ultimately the iron and humus become so concentrated that they form a thin, stone-like layer or **pan** which impedes the hitherto free drainage so that the A horizon becomes waterlogged during wet periods and develops a characteristic mottled appearance, with pale bluish colours predominant. This is largely attributed to ferrous compounds of iron formed under saturated, anaerobic conditions, in contrast to the

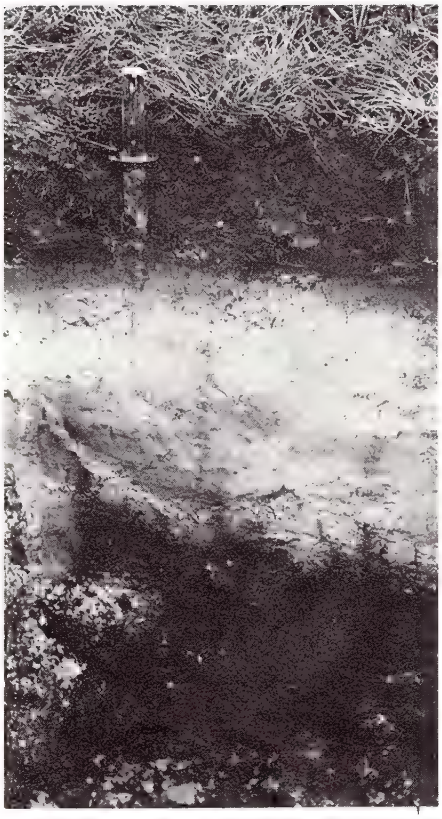


Fig. 16
This gley podzol soil supports pakihi vegetation at present, but it would have developed under forest. There is a thin layer of humus, corresponding to the handle of the knife. It is not readily distinguishable in the photograph from the underlying dark layer (corresponding to the blade) in which the mineral soil particles, although leached, are masked by the large humus component. The light-coloured horizon, some 30 cm thick, is silt that has been intensely leached and gleyed (see p. 48).

Below this, there is a strongly cemented horizon or pan, showing nearly black in the photograph because of fine humus particles washed down from higher levels in the soil. Weathering gravel, constituting the C horizon, shows at the base of the profile and also to the left of the pan; thin, wavy, reddish iron pans have been formed in this gravel.

G. Mew, Soil Bureau, DSIR.

more usual rusty ferric compounds. The process is known as gleying and the mature soils on the piedmont moraines, on surfaces in the order of 15 000 to 70 000 years old, are accordingly **gley podzols** (Fig. 16). On very wet sites, where drainage is poor from the outset, soils are true gleys.

Primary succession

The rise and decline of soil fertility and podzolisation are part of the process of succession on newly formed surfaces. Classic examples of such primary succession are taking place on the outwash gravels and moraines of the Franz Joseph and Fox Glaciers (Fig. 19-22). During the first few years, mosses (especially *Rhacomitrium*), lichens, and bright orange patches of the alga *Trentepohlia* gradually spread over the stones, and scattered seedlings of higher plants, mainly willow-herbs (*Epilobium*) and the mat plant *Raoulia*, become established on the finer material between the stones. As these cover more and more of the ground, they are joined by seedlings of shrubs, especially the broom *Carmichaelia grandiflora*, tree tutu (*Coriaria arborea*), akeake (*Olearia avicenniaefolia*), *Coprosma rugosa*, and koromiko (*Hebe salicifolia*). By 10 to 20 years, continuous scrub is developing, and seedlings of forest trees are beginning to appear, including those of rata (*Metrosideros umbellata*) and kamahi (*Weinmannia racemosa*). After 50 years, young rata and kamahi trees are beginning to overtop the dense growth of small trees and tall shrubs, and there are more forest species, mainly ones indicating relatively high levels of soil fertility; these include saplings of pate (*Schefflera digitata*), broadleaf (*Griselinia littoralis*), and mahoe, a lily (*Astelia fragrans*) with long green channelled leaves, the ferns *Phymatodes diversifolium*, *Blechnum capense*, and hen-and-chicken fern (*Asplenium bulbiferum*).

Forest of slender rata and kamahi trees covers prominent moraines formed 120 to 200 years ago which are crossed by the Douglas Track at Franz Josef Glacier and the Moraine Walk at Fox Glacier. A few podocarp seedlings enter this stage, but it is 500 years before one can speak of a podocarp forest, and even then the forest is still some way from what would be regarded as the **climax** stage, when it has reached its maximum complexity and attained the potential for maintaining its character indefinitely through successive generations of trees. In the climax forest, which can be seen on the track to Lake Wombat, the storied structure is well developed, and epiphytes and lianes are abundant. The soil already has the leached A horizon of a podzolised yellow-brown earth, especially on gentle slopes or flat ground, and species characteristic of younger, more fertile stages have been replaced by less demanding species. In particular, the main fern of the undergrowth is now crown fern (*Blechnum discolor*).

For the older part of the succession one must go to the piedmont moraines north-east of the Alpine Fault (Fig. 1, 17, 23-25). By 10 000 to 15 000 years, species tolerant of very low fertility begin to enter the forest, especially celery pine (*Phyllocladus alpinus*), umbrella fern (*Gleichenia cunninghamii*), and the small gahnia tussock

(*Gahnia procera*). Rimu becomes more abundant, and on flat, poorly drained sites forms almost pure stands of slow-growing trees, such as those that border the main highway south of Lake Wahapo. In foresters' parlance, this is "terrace rimu forest" which contains the greatest proportion of Westland's timber resources.

After a very long time, about 50 000 years, tall forest becomes restricted to the better-drained sites such as ridges and the banks of streams. Elsewhere there is a mosaic of woody and herbaceous vegetation. Stunted forest and scrub may be referred to as heath, because of the prevalence of slow-growing woody plants with small, hard, often scale-like leaves. It is dominated by manuka (*Leptospermum scoparium*), celery pine, and the small dacrydiums – yellow-silver pine (*Dacrydium intermedium*) on rises, pink (*D. biforme*) and silver (*D. colensoi*) pines in hollows. Wet grassland and bog vegetation consist of red tussock (*Chionochloa rubra*, a relative of the snow-tussocks), wire-rush (*Calorophus minor*), tangle fern (*Gleichenia circinata*), and the rush-like sedge *Baumea*, and include very dwarfed manuka, bog pine (*Dacrydium bidwillii*), and the creeping pygmy pine (*D. laxifolium*) which is the smallest of all conifers. Nitrogen is in short supply in these habitats, and four species overcome this by trapping and digesting small animals. These are the three kinds of sundew (*Drosera*) which trap insects on the sticky, glandular hairs of their leaves, and bladderwort (*Utricularia novae-zelandiae*) which sets its traps in the mud, in the form of small sacs. Where drainage is poorest, there are patches of cushion bog dominated by comb-sedges (*Oreobolus*), *Donatia novae-zelandiae*, and *Centrolepis ciliata*; this is a community that one would normally expect at much higher altitudes.

Soil under this herbaceous vegetation typically has little surface peat, but consists of 20 to 80 cm of wet, puggy silt loam leached to a light grey colour, which is separated from weathering gravel below by a reddish, impervious, rock-hard iron pan less than 1 cm thick. Under scrub and forest, soils are deeper, and the organic layer especially is usually thicker. In mature gley podzols, nutrients accessible to plants are nearly confined to the litter, humus, and peat, and the extreme infertility that prevails on these old surfaces probably results from the loss of the organic layer during the last period of severe climate and major glaciation.

Fig. 17 **Habitat VI.** Heathland. On rolling topography moulded by the piedmont glacial advance, there is a mosaic of vegetation determined by soil conditions. On poorly drained gley podzols in the foreground depression, wire-rush (*Calorophus minor*) and tangle fern (*Gleichenia circinata*) are conspicuous, with red tussock (*Chionochloa rubra*) behind them on the right. Manuka (*Leptospermum scoparium*) fringes the far margin of the depression. The low ridge in the middle distance supports scrubby forest with species of *Dacrydium* and celery pine (*Phyllocladus alpinus*); two trees of kaikawaka (*Libocedrus bidwillii*) are conspicuous at the left.

Tall forest grows on the higher, steeper ridge behind and is dominated by podocarps, especially rimu (*Dacrydium cupressinum*), and the tall hardwoods – southern rata (*Metrosideros umbellata*) and kamahi (*Weinmannia racemosa*). To the east, across the Alpine Fault, outer ranges of the Southern Alps rise to alpine grassland and snowy summits.

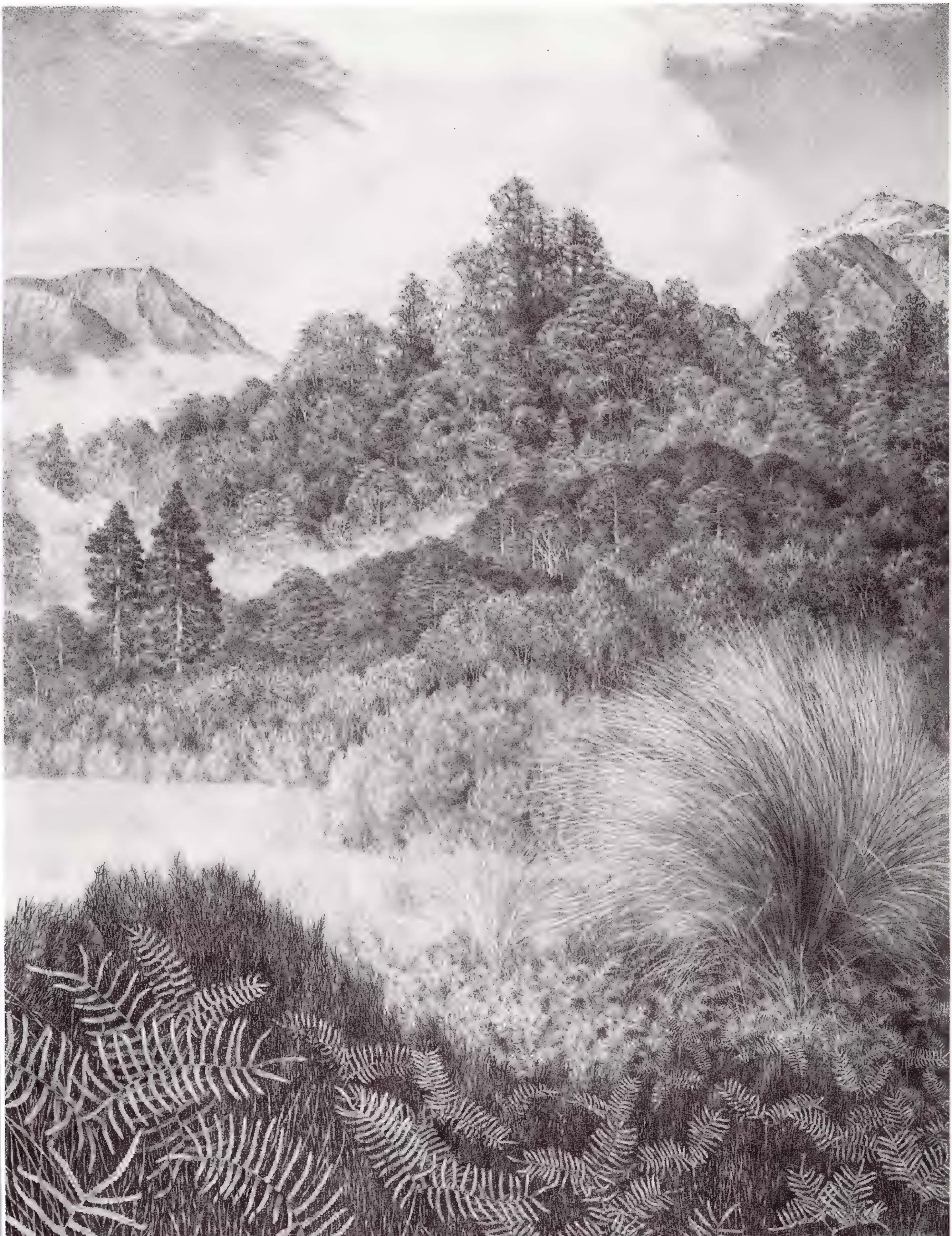

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Fig. 18 The melting, gravel-covered snout of the Balfour Glacier is in the left foreground. Behind this, extending to the centre of the photograph there is a cluster of four small moraine ridges formed between 1940 and 1965. Small shrubs of inaka (*Dracophyllum longifolium*) are visible in the troughs between them. Further back there is coarser moraine, with patches of taller scrub; the nearest ridge of this moraine was formed between 1900 and 1920.

Tables A6 and A7 in Appendix 1 list species characteristic of early and late stages of this sequence; those of the climax stage are shown in Table A1.

Sequences of moraines left by other glaciers in the park demonstrate plant successions at higher altitudes. Terminal moraines at the Balfour Glacier (Fig. 18) show development of subalpine scrub, for though they lie at only 700 m above sea level, flow of cold air depresses the vegetation belts on the valley floor. Seedlings of inaka (*Dracophyllum longifolium*) and other shrubs begin to appear within 15 years, and the scrub becomes gradually taller and denser. Most of the oldest moraine, which was formed during the seventeenth century A.D., supports low forest of broadleaf, inaka, and neinei (*Dracophyllum traversii*), with young rata trees on the highest parts.

There is a similar succession to tall subalpine scrub on moraines of comparable age at the La Perouse Glacier, at around 900 m. However, troughs between the moraines develop towards grassland which by 300 years is dominated by pale-leaved snow-tussock (*Chionochloa pallens*). The La Perouse Glacier has also left much older

moraines, ranging in age from 1500 to 5000 years, and on these the soil deteriorates towards a gley podzol. Tall, dense scrub becomes gradually restricted to the steeper moraine slopes, and plants more tolerant of low fertility appear, such as celery pine and leatherwood (*Olearia colensoi*). Rolling moraine crests develop a mosaic of shrubs, narrow-leaved snow-tussock (*Chionochloa* cf. *rigida*), and turfy plants indicating leached, poorly drained conditions. Troughs between the old moraines have peat bogs with mountain sedges such as *Carex gaudichaudiana* and *Carpha alpina*, and mosses including *Sphagnum*. Radio-carbon dates on the basal peats enabled the sequence to be dated.

The higher moraine crests of the Strauchon Glacier, at 1150 m, have grassland of pale-leaved snow-tussock little different from that on the adjacent mountain slopes. The Fitzgerald Glacier has left a terminal loop at 1250 m, which can be dated from old photographs to about 1890. Plant cover is still meagre today, with occasional lichens encrusting rocks, and scattered alpine herbs and grasses.

The Strachan Glacier flows from the Hooker Range towards the Landsborough River and terminates in silver beech forest. Because it is easy to extract cores of wood from beech trees and to count the number of annual growth rings, this glacier has provided accurate dating of moraines back to A.D. 1600 and insight into the development of beech forest from the first scattered seedlings on bare moraine to mature forest.

Apart from the moraines, there are limited areas on broad and gently rolling ridge crests, saddles, and spurs where soils have been stable long enough to have become moderately gleyed and podzolised. Below 1200 m the vegetation is the same mosaic of shrubs, tussocks, and herbs that occupy the crests of the oldest La Perouse moraines. At higher altitudes, a grass (*Chionochloa crassiuscula*), with short tapering leaves that curl at the tips in dry weather, dominates similar sites. Accompanying plants include a small marsh-marigold (*Caltha novae-zelandiae*), a dwarf lily (*Astelia linearis*), and a comb-sedge (*Oreobolus impar*). This community is also extensive on shallow alpine soils where drainage is impeded by underlying rock. The slopes are often very steep, and the slippery leaves of *C. crassiuscula* form a treacherous sward.

In Westland National Park, plant successions on landslide debris, steep bouldery fans, and talus slopes are the most widespread. Vegetation and soil progress through the same early stages as on moraine, but there is a tendency for downward creep of the soil mantle to churn freshly weathering rock up from the lower horizons, thereby counteracting the effects of leaching. In the lowland and montane belts, soils do not develop beyond the yellow-brown earth stage under these conditions, and climax vegetation persists indefinitely. This is generally kamahi forest with a scattered overstorey of podocarps. At higher altitudes, weathering and soil development are slower. The pale-leaved snow-tussock grassland that is climax vegetation on low-alpine slopes grows on weakly weathered greyish-brown loam, and in the high-alpine belt even the most stable soils have an unweathered appearance.

Continual movement of the mantle is even more pronounced in steep gullies and gorges, and along fault scarps where the substratum is shattered and unstable. Soils here consist largely of angular, unweathered fragments of rock. At low altitudes the dominant vegetation is scrubby forest of fuchsia, mahoe, and pate with undergrowth of hen-and-chicken fern; in the subalpine belt this is replaced by mountain ribbonwood (*Hoheria glabrata*) with undergrowth of shield fern (*Polystichum vestitum*) (Table A8). A soft, summer-green bracken-like fern (*Hypolepis millefolium*), a narrow-leaved tussock (*Poa cockayniana*), and broad-leaved snow-tussock (*Chionochloa* cf. *flavescens*) grow on equivalent low-alpine sites.

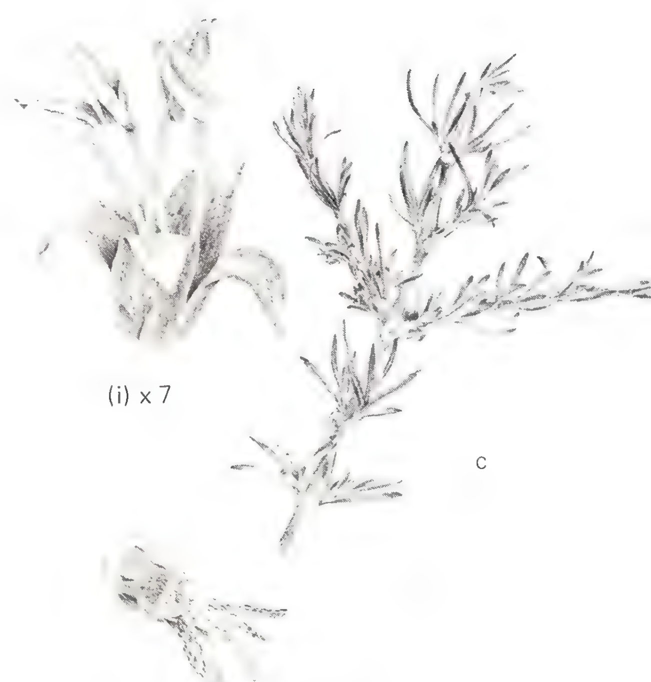
Rock outcrops dominate much of the mountain scenery of the national park and include bluffs too steep for soil to gather, places where landslides have removed the soil mantle, and "roches moutonnées" where glaciers have scraped away the over-burden. Succession on bare rock can be seen to perfection in the valley of the Franz Josef Glacier. Mosses and encrusting lichens form the earliest cover, the former on moister and more shaded rock, the latter on the more exposed. Seedlings of vascular plants appear within a few years in fissures and on ledges where sand and gravel provide root-holds. Closure of plant cover is very slow, and on Sentinel Rock, which has been free of ice since 1860, there are still bare rock and areas where moss predominates. Reduced competition among the vascular plants allows a remarkable mixture of species which would otherwise be expected in quite different communities. The epiphytic lowland orchids *Earina* and *Dendrobium* can be seen on the same cliff as the alpine *Celmisia bellidioides*; and forest trees such as rata and kamahi grow beside pioneer herbs.

Even quite steep cliffs can support a continuous, if rather precarious cover of vegetation which at low altitudes is likely to be rata forest. Often, however, bare rock forms a mosaic with vegetation occupying ledges and fissures. Some of the most attractive vegetation in the park is on such rock outcrops at the top of the subalpine belt, about 1200 m. Celmisias (e.g., *C. coriacea*, *C. du-rietzii*, *C. armstrongii*), native "foxglove" (*Ourisia macrocarpa*), the rock-clinging, glaucous *Dracophyllum kirkii*, *D. fiordense* with great tufts of leaves borne on erect, naked stems, broad-leaved snow-tussock, the large speargrass *Aciphylla horrida*, and many others all display to maximum advantage in these veritable rock gardens.

In various places in the Karangarua catchment, the passage of the glaciers left expanses of bare, hard schist rock that has resisted weathering through post-glacial time. The few centimetres of soil that have accumulated have been intensely weathered, and the underlying rock has the same effect on drainage as an iron pan. Conditions for plants are the same as on the extreme gley podzols of ancient piedmont moraines. Consequently, the shallowest soils support bogs with comb-sedges, sundews, and suchlike, and on the deepest soils there is stunted forest with pink and silver pines, manuka, and rata. On the southern bank of the Karangarua River, between the falls and Lame Duck Flat, this mosaic occupies 400 ha and has silver beech as an important constituent of the forest and scrub (Fig. 38).

Vertical faces of alluvial and glacial gravel, such as those that border the larger rivers in their middle reaches, develop a cover of vegetation that is surprisingly complete considering the steepness and apparent instability. Nearly bared gravel is first colonised by mosses, especially the robust, reddish-brown *Polytrichadelphus magellanicus*, and by grey lichens (*Stereocaulon*) with an erect, branching habit. These are followed soon by trailing plants of *Gunnera monoica*. Eventually the fern *Blechnum capense* dominates and is usually accompanied by the everlasting daisy *Gnaphalium trinerve* and often by festoons of clubmoss (*Lycopodium volubile*, Fig. 9). Shrubs and trees also gain root holds but are usually pulled out by their own weight before they reach maturity. An identical succession takes place on road cuttings.

a



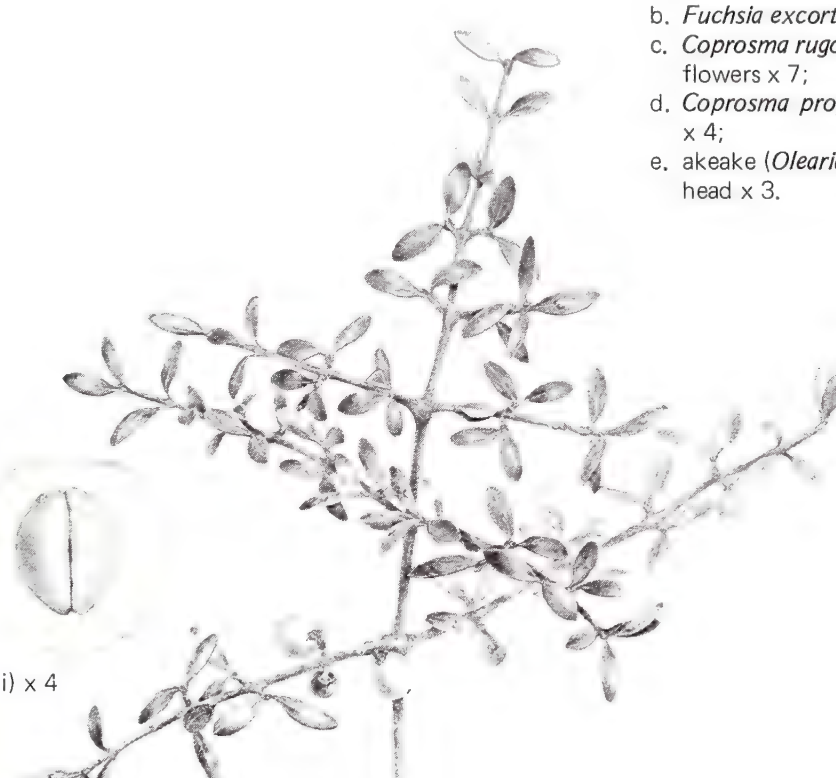
c

(i) x 3

e x 1/2

Fig. 19
Successional plants

a. native broom (*Carmichaelia* cf. *grandiflora*), (i) root nodules;
b. *Fuchsia excorticata*;
c. *Coprosma rugosa*, (i) and (ii) male and female flowers x 7;
d. *Coprosma propinqua*, (i) seeds within berry x 4;
e. akeake (*Olearia avicenniaefolia*) x 1/2, (i) seed head x 3.



(i) x 4

d

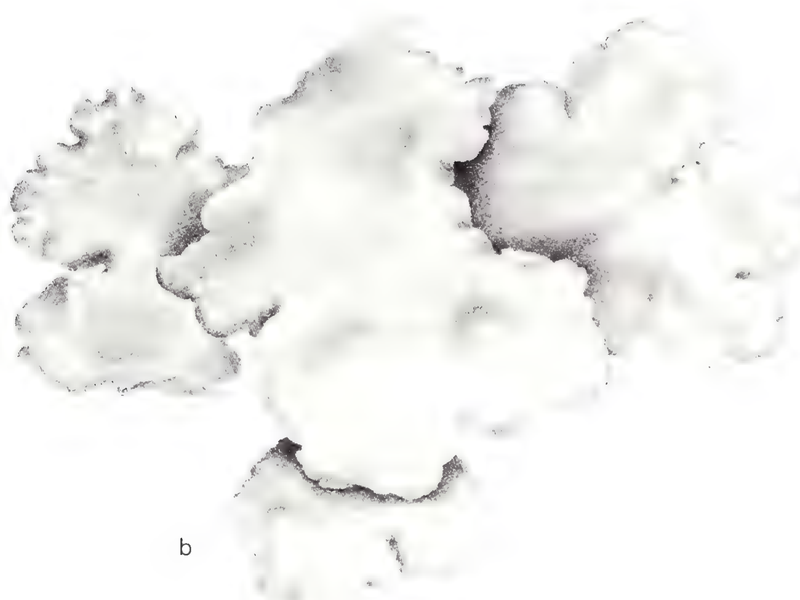
(i)

a x 2/3

b

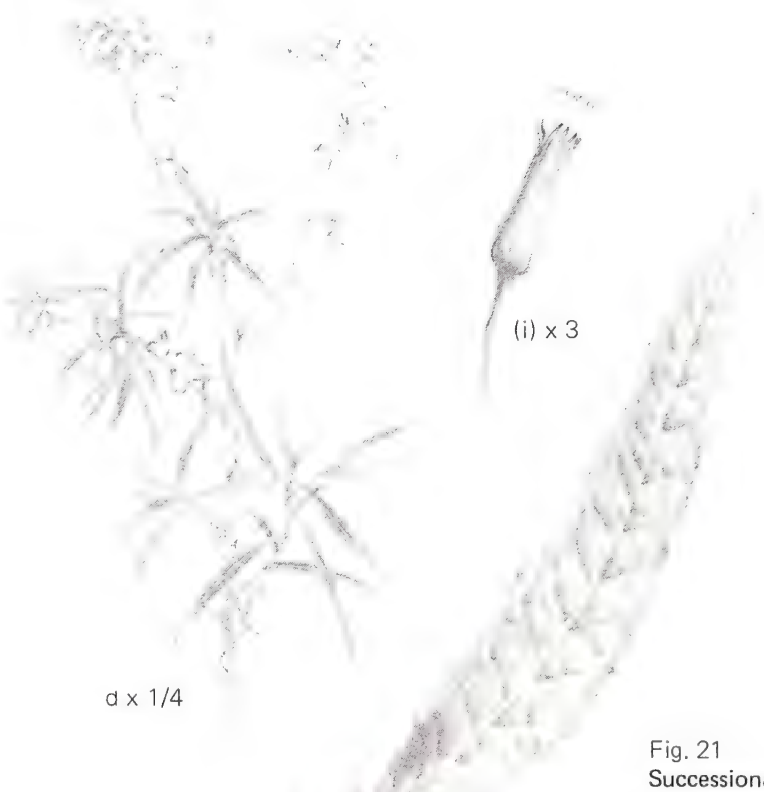
Fig. 20
Successional plants ctd.
a. tutu (*Coriaria arborea*) x 2/3, (i) root nodules;
b. koromiko (*Hebe salicifolia*).

a



b

c



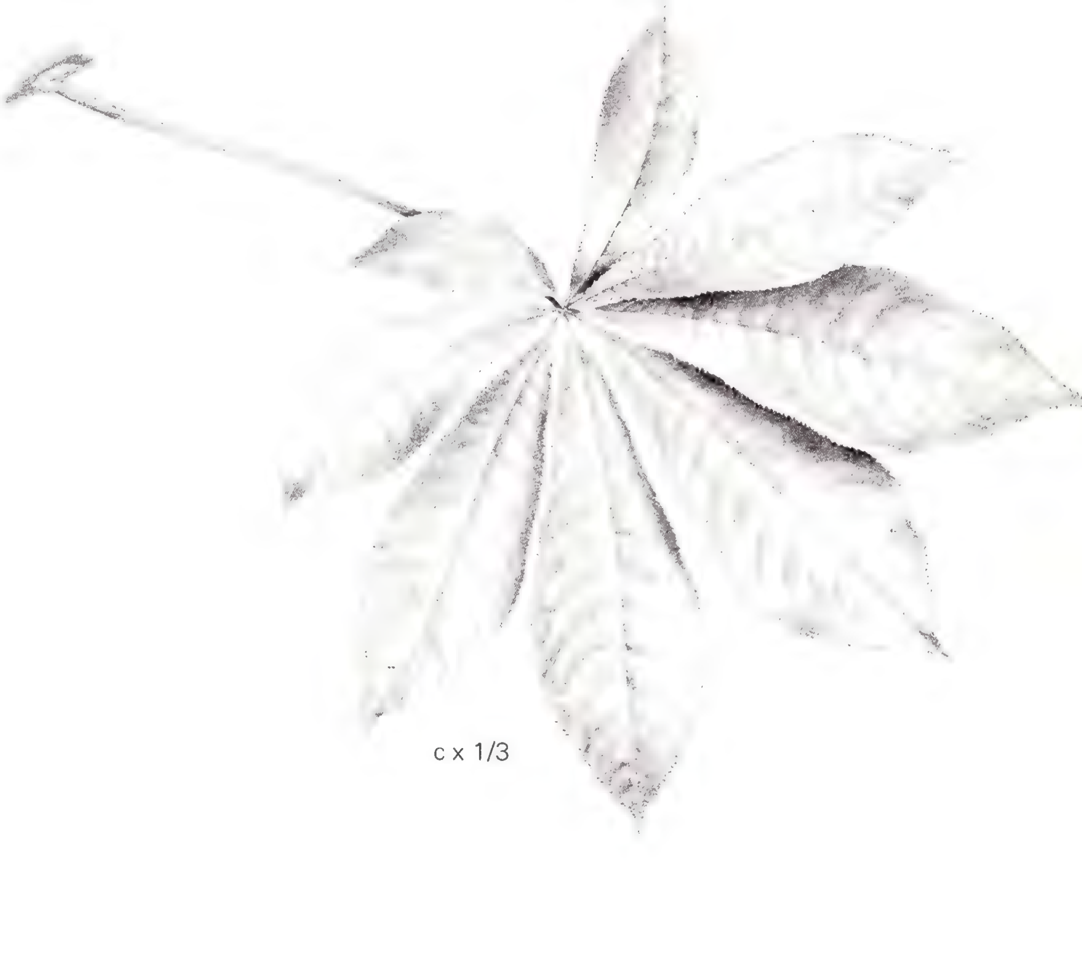
d x 1/4

Fig. 21
Successional plants ctd.
a. wineberry (*Aristotelia serrata*);
b. thallose liverwort (*Monoclea forsteri*);
c. marbleleaf (*Carpodetus serratus*);
d. *Senecio minimus* x 1/4, (i) flower head x 3, (ii) leaf x 2/3;

Fig. 22
Successional plants ctd.

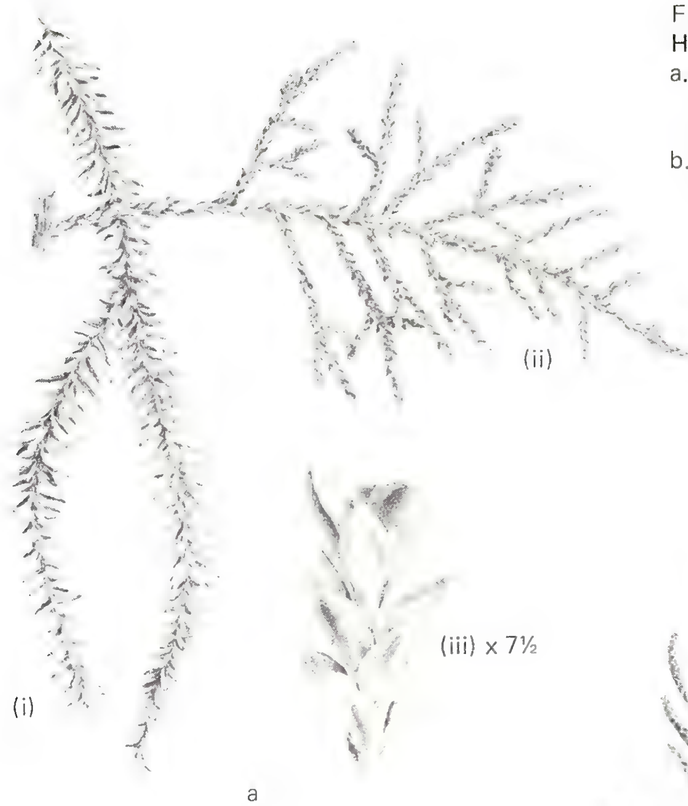
a. hen-and-chicken fern (*Asplenium bulbiferum*) x 1/3, (i) marginal plantlet x 2;
b. mahoe (*Melicytus ramiflorus*) x 1/2, (i) fruit;
c. pate (*Schefflera digitata*) x 1/3.

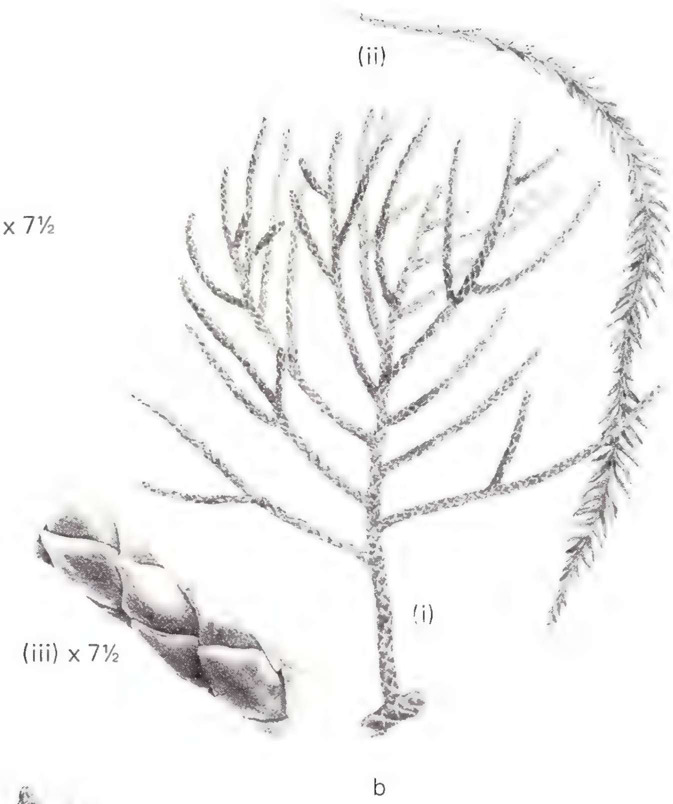
b x 1/2

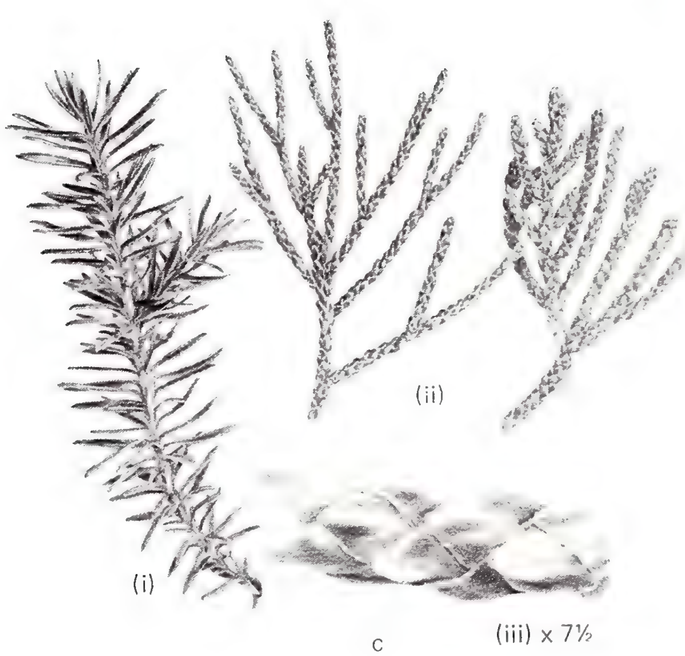


c x 1/3

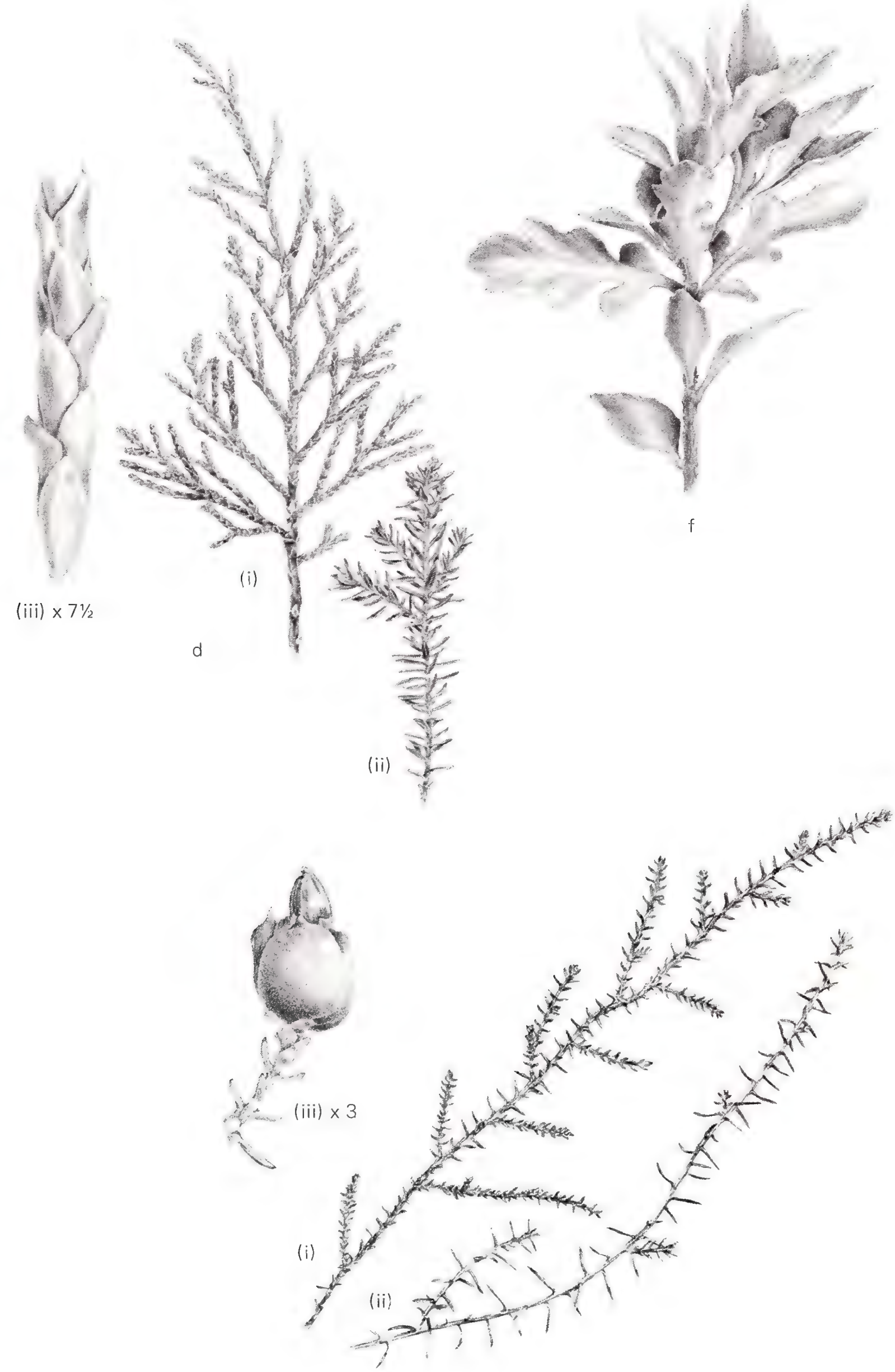
Fig. 23
Heathland conifers
a. yellow-silver pine (*Dacrydium intermedium*), (i) and (ii) juvenile and adult foliage, (iii) detail of (ii) x 7½;
b. silver pine (*Dacrydium colensoi*), (i) and (ii) adult and juvenile foliage, (iii) detail of (i) x 7½;



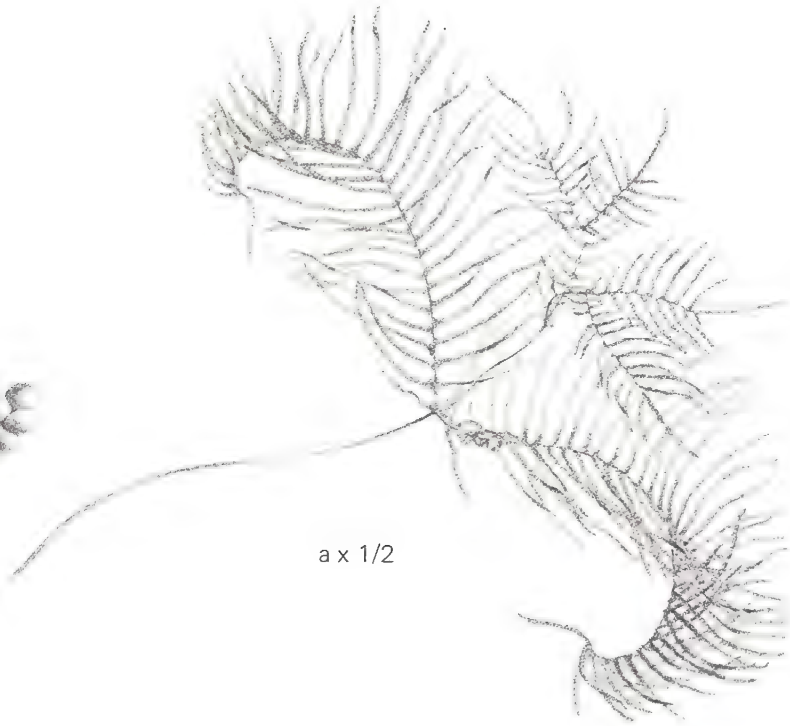




c. pink pine (*Dacrydium biforme*), (i) and (ii) juvenile and adult foliage, (iii) detail of (ii) x 7½;
d. bog pine (*Dacrydium bidwillii*), (i) and (ii) adult and juvenile foliage, (iii) detail of (i) x 7½;
e. pygmy pine (*Dacrydium laxifolium*), (i) and (ii) exposed and shaded twigs, (iii) cone x 3;
f. celery pine (*Phyllocladus alpinus*).


(iii) x 7½
(i)
d
(ii)
f
(iii) x 3
(i)
(ii)
e

(i) x 5



a x 1/2

b x 1/3

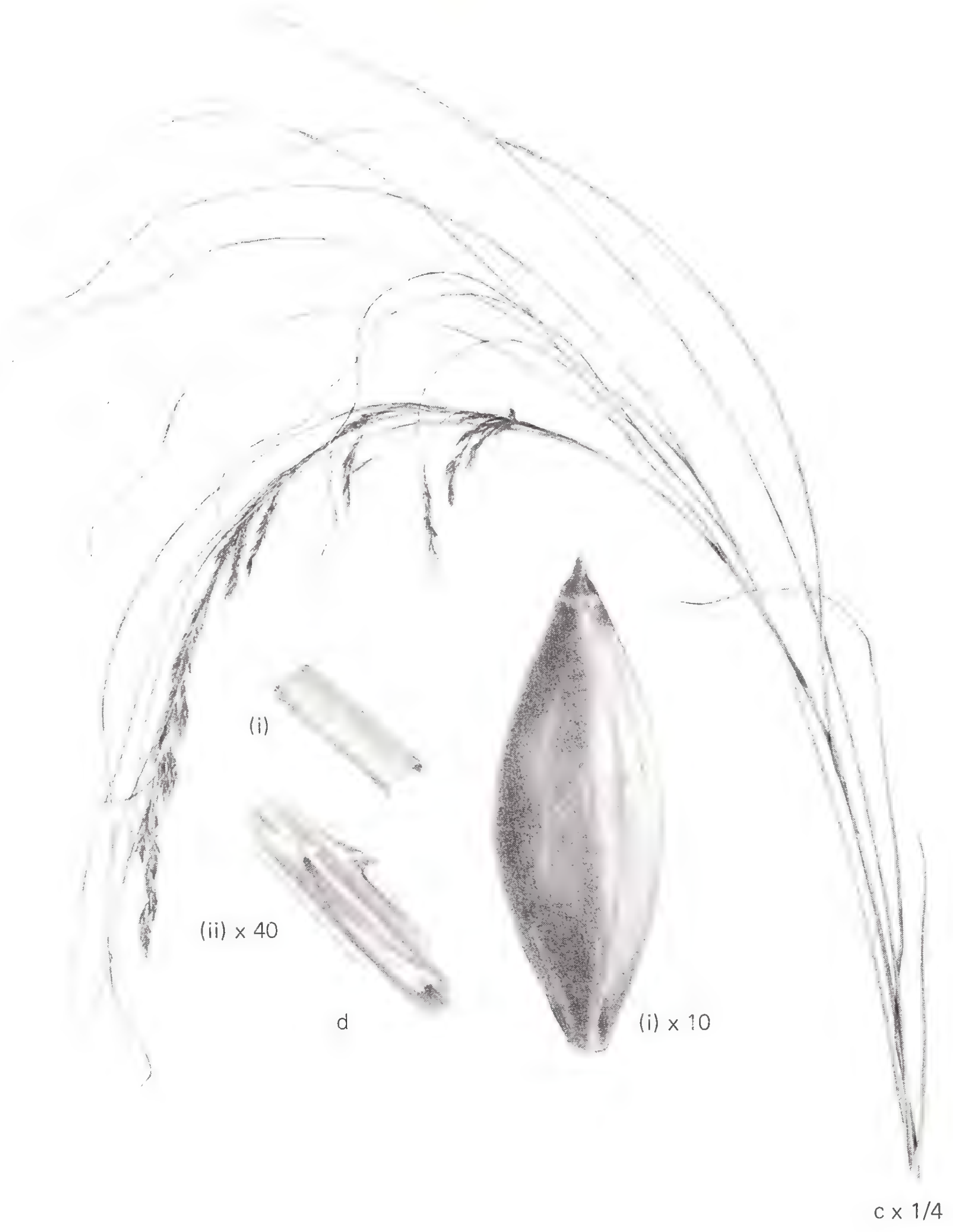


Fig. 24
Heathland plants
a. tangle-fern (*Gleichenia circinata*) x 1/2, (i) detail of frond segment x 5;
b. umbrella-fern (*Gleichenia cunninghamii*) x 1/3;
c. *Gahnia procera* x 1/4, (i) seed x 10;
d. *Gahnia rigida*, (i) section of leaf, (ii) detail of leaf serrations x 40.


a x 1/4
(i)
(ii) x 2
b x 1/2
(i)
c
(i) x 5

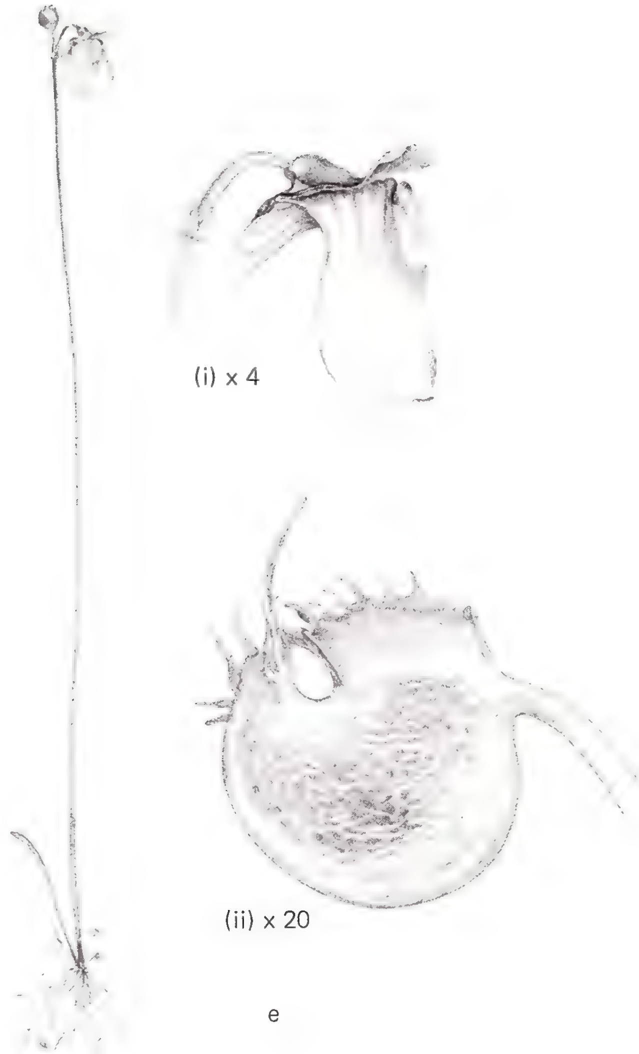


Fig. 25
Heathland plants ctd.

a. comb-sedge (*Oreobolus pectinatus*) x 1/4, (i) stem and leaves, (ii) leaf x 2;
b. sundew (*Drosera binata*) with seed capsules x 1/2, (i) leaf.
c. wire-rush (*Calorophus minor*), (i) detail of stem-leaf junction x 5;
d. *Baumea teretifolia* x 1/3, (i) detail of inflorescence;
e. bladderwort (*Utricularia novae-zelandiae*), (i) flower x 4, (ii) bladder x 20;

3

Flood plains, swamps, and lakes

The main lowland valleys are built up from gravel, silt, and peat which filled the lakes and fiords left during the final retreat of the ice-age glaciers. The final stages of deposition, and subsequent changes in the courses of the rivers, have given rise to the pattern of soils and vegetation that we see today. This is a complex pattern, depending primarily on subtle differences in drainage.

The first stages of primary succession can be seen on recently abandoned river beds (Fig. 27-28). The early pioneers on stony ground are the raoulias and willow-herbs (*Epilobium*), and these are succeeded by native and introduced grasses, clovers, and seedlings of shrubs, especially coprosmas such as *Coprosma propinqua*. Unfortunately, gorse (*Ulex europaeus*) is also a vigorous pioneer on these river beds, and, although there are still valleys and flats free of it, it is spreading rapidly. Silty deposits tend to be colonised by coarse grasses, namely toetoe (*Cortaderia richardii*), distinguished by its tall, feathery plumes, and the introduced tall fescue (*Festuca arundinacea*), as well as the large yellow-flowered clover, *Lotus pedunculatus*. Hollows which collect water are soon dominated by small sedges, rushes (especially the introduced *Juncus articulatus*, Fig. 31), and the introduced water forget-me-not (*Myosotis caespitosa*). These pioneer communities are rich in plant species (Table A9, Appendix 1). More than 60 were listed from a few square metres on the Cook River flats.

With time these soils tend to become increasingly swampy, because the vegetation impedes drainage and traps silt during floods and dust during dry, windy weather, and because sand and silt disintegrate to finer particles. On stony areas that remain well drained, the pioneer scrub is succeeded by Westland totara (*Podocarpus totara* var. *waihoensis*) which is joined later by increasing numbers of other podocarps, especially kahikatea (*Podocarpus dacrydioides*), and matai (*P. spicatus*). On heavier, wetter soils, forest of hardwoods develop, comprising species such as kaikomako (*Pennantia corymbosa*) and lowland ribbonwood (*Plagianthus betulinus*), and this shelters numerous kahikatea seedlings (Fig. 29-30). In this way, the dense stands of kahikatea which are still such a feature of the South Westland river valleys have arisen. Where kahikatea trees are closely spaced, there may be little beneath them except moss, but swampy openings support smaller trees and shrubs, a large astelia (*A. grandis*), and, near the coast, tangles of kiekie (*Freycinetia banksii*) and supple-jack (*Ripogonum scandens*) and huge tussocks of *Gahnia xanthocarpa*, a sedge with

razor-sharp leaves. Along the meandering tidal reaches of the Waitangiroto and Ohinetamatea Rivers, which flow between banks 1 to 3 m high, the silty soils are well drained but subject to occasional floods which deposit fresh silt, and these conditions favour hardwood forest. Here, only occasional podocarp seedlings become established, but these develop into giants with massive crowns.

Grassy enclaves persist a long time on the river flats and, while today this partly results from management of the flats for grazing, it is none the less a long-standing feature, for such grassy areas were noted and welcomed by the earliest European explorers. Nor do woody plants colonise areas which are flooded most or all of the time, and on these there develops true swamp vegetation of rushes, creeping sedges such as *Carex coriacea* (Fig. 31), tufted sedges like the niggerhead (*C. secta*) with its tussock of leaves borne on a "trunk" formed of tightly packed roots and shoot bases, and *Phormium tenax*. In these relatively fertile swamps the acidity of the water is only a little greater than that of rain water, and there has been little leaching of nutrients. However, raupo or bulrush (*Typha orientalis*) is remarkably scarce, probably because the swamp waters are renewed so rapidly in this wet climate that insufficient nutrients accumulate.

The kinds of forest and swamp described so far are less than 1000 years old, and have not advanced beyond an early stage of ecological development. With time, the usual processes of leaching and gleying take place, and organic matter accumulates; not, as a rule as surface peat, but as fine particles incorporated into the upper part of the mineral soil. There are areas of flat terrain in the main valleys, usually well away from the major rivers, which are older but still post-dating the retreat of the ice-age glaciers. The largest of these is a swampy plain lying between the Cook and Karangarua Valleys, but separated from them by ridges of moraine. Through it, the Ohinetamatea River follows a winding, deeply incised course. On either side of the river there is hardwood forest with scattered podocarps and, where wetter, dense forest of kahikatea. Further from the river, drainage is poor, but there is still little surface water; and the forest grades from dominance by kahikatea to nearly pure forest of dense rimu (*Dacrydium cupressinum*), similar to that of gley podzol soils on terraces. The trees, although over 30 m tall, are shallowly rooted in the surface humus, beneath which there are often over 3 m of semi-liquid mud overlying the firmer, silty substratum.

Where permanent pools lie on the surface, the rimu trees are smaller and share dominance with silver pine (*Dacrydium colensoi*). Still wetter areas support manuka (*Leptospermum scoparium*) and small silver pines, and this is often marginal to infertile swamp with acidic water dominated by a rush-like sedge (*Baumea rubiginosa*) and wire-rush (*Calorophus minor*). Slightly higher ground within the swamps usually supports large green tussocks of the sedge *Gahnia rigida*, as well as stunted plants of manuka, silver pine, and, locally, bog pine (*Dacrydium bidwillii*).

Smaller tributary streams are not deeply incised like the Ohinetamatea River, so that the whole sequence is wetter. The streams are followed by "gallery forests" only a few metres wide of tall kahikatea, and these grade into infertile swamp via transitional

Fig. 26 Most acid swamps have been burnt from time to time, so that the vegetation becomes a mixture of *Baumea*, tangle fern (*Gleichenia circinata*), young manuka (*Leptospermum scoparium*), and stunted *Phormium tenax*. On the left of this photograph, the swamp meets kahikatea (*Podocarpus dacrydioides*) forest which borders the Waitangiroto River, and, on the right, there is a long moraine ridge with forest largely of rimu (*Dacrydium cupressinum*) and kamahi (*Weinmannia racemosa*).

vegetation dominated by silver pine, manuka, celery pine (*Phyllocladus alpinus*), and stunted kahikatea. A similar sequence of communities from hardwood and kahikatea forests to sedge, *Phormium tenax*, and infertile swamps also occupies the catchment of the Waitangiroto River and includes the nesting site of the white and spoonbill herons (Fig. 26).

Land surfaces older than the most recent great advance of the glaciers consist mainly of rolling moraine on the extensive piedmont plateaux, and the degradation of soils and vegetation on these was described in the preceding chapter. Flat areas, representing old outwash surfaces, have shared in this degradation, and because they are especially poorly drained, support mainly herbaceous vegetation. Scrub occurs where drainage is slightly better, and gallery forest of rimu follows streams. Even on this flat terrain, there is little peat overlying the leached upper layer of the mineral soil, except in depressions that once contained lakes.

Lakes also represent an early stage of geological and ecological development. Shallow open water supports three categories of plants. Fully submerged species include *Lilaeopsis* (Fig. 31), a plant of the carrot family which, however, can only produce its characteristic umbel of flowers and fruits when growing in shallow pools liable to dry up; *Isoetes alpinus*, a tufted, rush-like plant, but the sacs of spores at the bases of its leaves show it to be a relative of the club-mosses (*Lycopodium*); *Chara* and *Nitella*, green algae consisting of fine, jointed tubes, each section of several centimetres length being a gigantic single cell; and *Lepilaena bilocularis*, which has thread-like leaves scarcely thicker than algal filaments. A second category includes plants with two kinds of leaves, one submerged and the other floating. The shoots bearing the latter also bear the inflorescences which are held above the surface of the water to benefit from pollination by flying insects. Two species of *Potamogeton* have oval, undivided floating leaves, and *Myriophyllum* has long stems with numerous whorls of leaves, the submerged ones being divided into fine segments, and the floating ones being less divided or entire. Finally, there are reed-like plants which thrust boldly into the air. These include *Eleocharis sphacelata* with soft, rush-like stems 2 m tall and 1 cm thick and the much more slender *E. acuta* (Fig. 31) with stems which tend to collapse on to the surface of the water. True floating plants such as duck weed (*Wolffia*) and pond fern (*Azolla*) seem to be absent from the district, presumably because of the low nutrient content of the water.

Small lakes gradually become filled with peat and mud, especially as swamp vegetation extends in from their margins. An early stage of this occurs at Peters Pool which is a **kettlehole** or depression where a mass of ice buried in moraine and sediments melted during the retreat of the Franz Josef Glacier about 120 years ago. Here, a floating mat of a sedge, *Carex gaudichaudiana*, borders the rooted marginal vegetation. Eventually, this floating border will become firm and peaty enough to support seedlings of other plants.

On much older surfaces, former ponds and small lakes have been nearly or quite obliterated. A good example is a deep kettlehole, dating from the final retreat of the ice-age glaciers, beside the road to Gillespies Beach. Here, the surrounding terrace

rimu forest grades via low forest, dominated by pink pine (*Dacrydium biforme*) and silver pine, to infertile swamp growing on 7 m of peaty mud, but there is still open water at the centre.

Deeper, larger bodies of water, such as Lakes Mapourika, Wahapo, and Matheson and the upland Lakes Mueller and Gault, support only a sparse growth of water plants, because of their depth, wave-cleansing of their shores, and a very low content of nutrients. In particular, the absence of floating and emergent plants is a valuable feature of these lakes, from the viewpoint of scenery, fishing, boating, and swimming. This state could alter, if the lakes were to become enriched in nutrients through run-off from farms or effluent from settlements, or if there were further accidental introductions of aggressive water weeds. Cape pondweed (*Aponogeton distachyus*) is already abundant in Lake Mahinapua near Hokitika and, regrettably, oxygen weed (*Elodea canadensis*, Fig. 30) was found to be well established in Lake Mapourika in 1974.

In many places, lake floors plunge steeply from the surrounding hills, providing little transition between forest and the aquatic habitat. At other margins, especially where streams are building deltas, the lake waters merge into swamps of *Phormium tenax* and sedges or even into kahikatea forest as at the northern end of Lake Wahapo. There are also gently sloping, stable shores of fine gravel, sand, or silt that fluctuating lake levels alternately flood or expose. These have a distinctive turfy vegetation of tiny, creeping flowering plants, especially *Glossostigma elatinoides*, *Hypsela rivalis*, small species of *Scirpus*, and stunted plants of *Lilaeopsis*. On the other hand, where the action of wind and waves has built a beach of coarse pebbles, there may be little in the shoreline zone other than robust tussocks of the jointed rush *Leptocarpus similis*, a plant that is more characteristic of coastal marshes.

Two extremes in aquatic plant communities are the algal cells growing singly or as simple chains in the hot springs at Welcome Flat at temperatures of up to 50°C and the algae responsible for red snow (p. 17). Those in the hot pools form a fibrous scum and mainly belong to the primitive but adaptable blue-green class. The snow algae are single-celled green algae in which the chlorophyll is masked by red pigment.


a
(i)
b
(ii) x 5
(i) x 3
c
(i) x 5
d
(i) x 2
e

Fig. 27
Plants of open river flats
a. willow-herb (*Epilobium glabellum*), (i) leaf;
b. *Cyathodes fraseri*, (i) fruit x 3, (ii) leaf underside x 5;
c. *Gunnera dentata*;
d. *Stellaria gracilenta*, (i) detail of leaves and shoot x 5;
e. *Pernettya macrostigma*, (i) fruit x 2;
f. *Raoulia tenuicaulis*, (i) detail of shoot and flower head x 5;
g. *Rubus parvus*;
h. *Coprosma brunnea* in fruit.

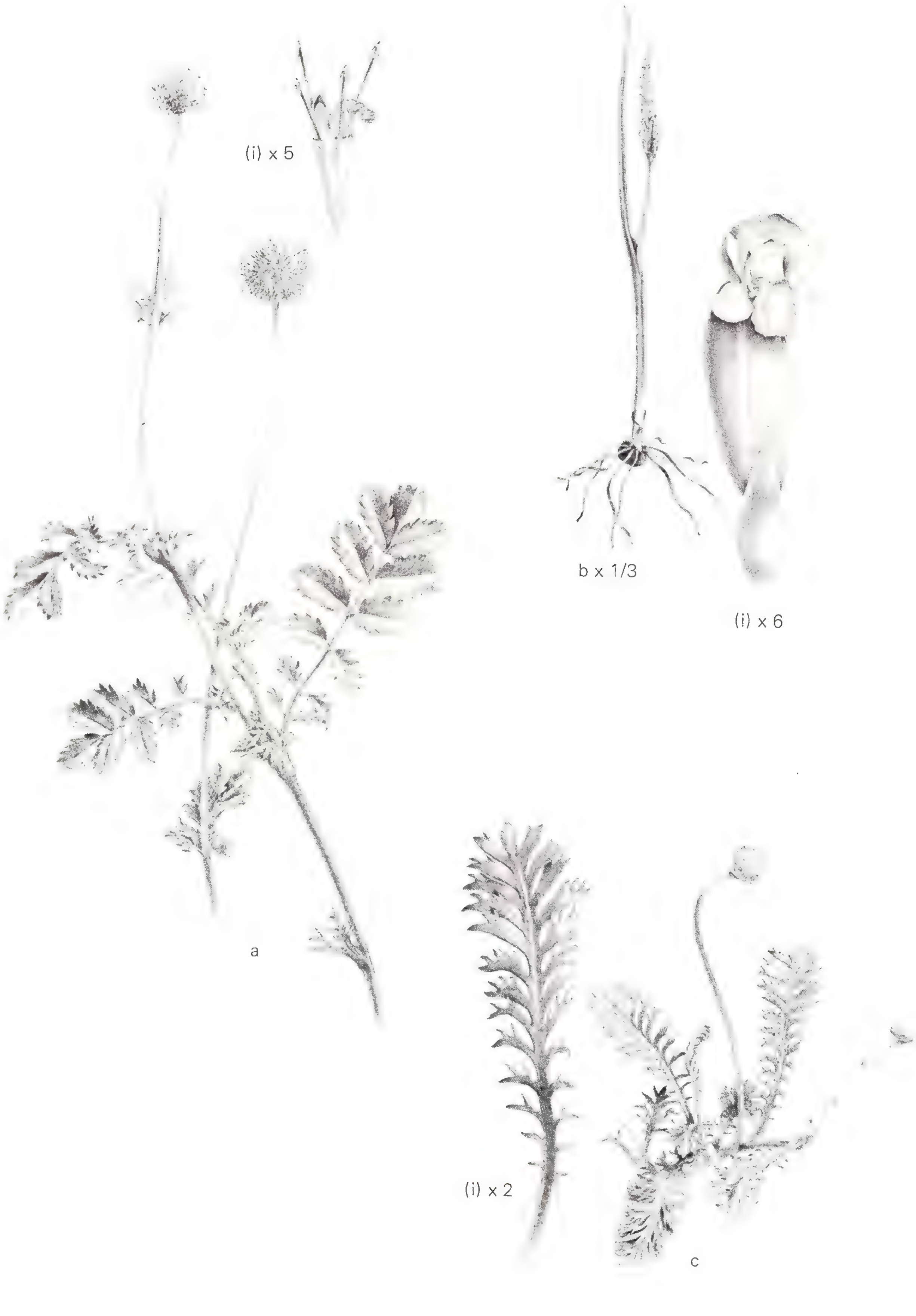
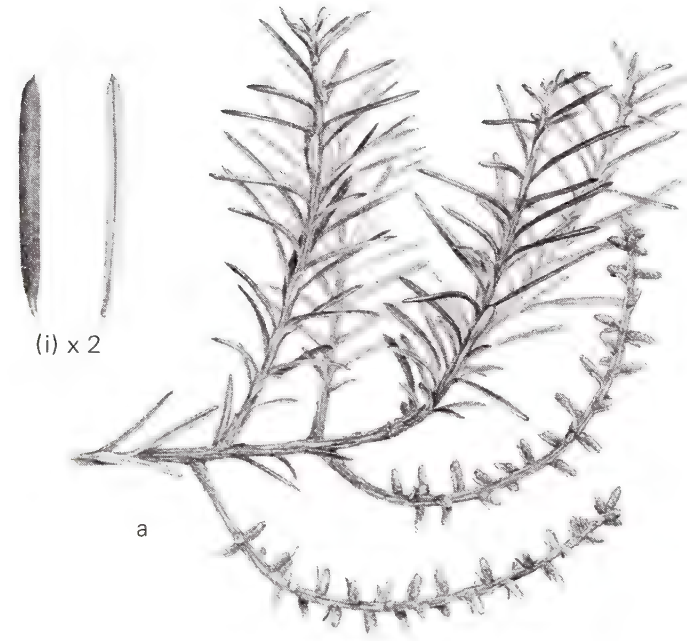

(i) x 5
b x 1/3
(i) x 6
a
(i) x 2
c

Fig. 28

Plants of open river flats ctd.

a. bidibid (*Acaena anserinifolia*), (i) fruit x 5;
b. *Microtis unifolia* x 1/3, (i) flower x 6;
c. *Cotula squalida*, (i) leaf x 2;
d. *Lotus pedunculatus*;
e. *Cerastium holosteoides*, (i) ripe seed capsule x 5.


(i) x 2
a

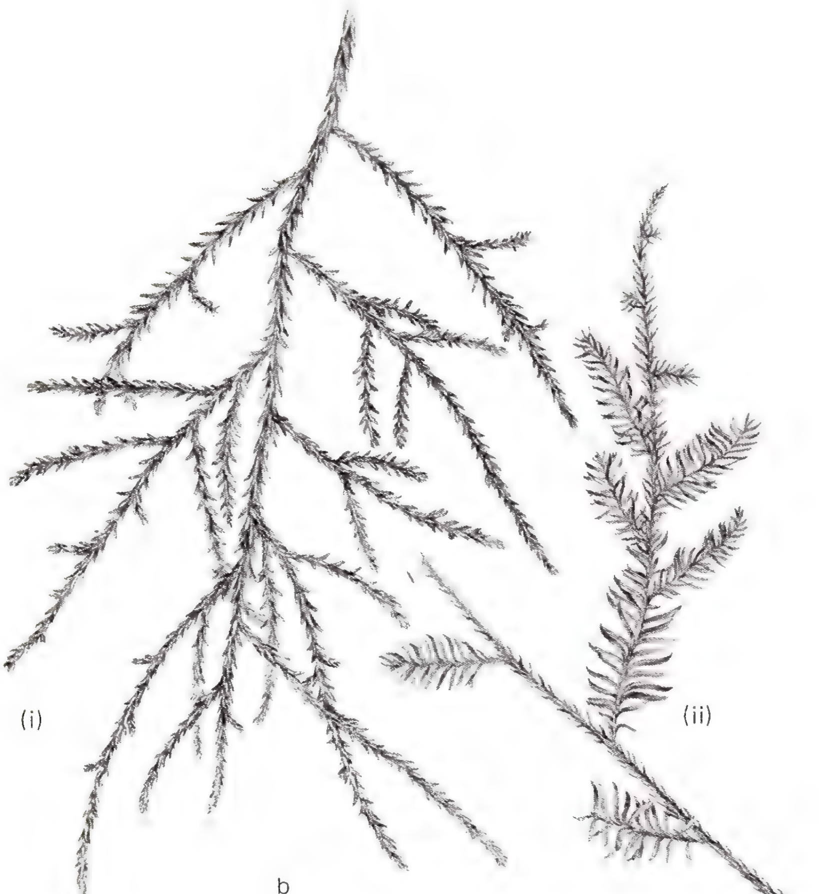

(i)
(ii)
b

Fig. 29

Trees of lowland river flats

a. matai (*Podocarpus spicatus*) with immature male catkins, (i) leaves x 2;
b. Kahikatea (*Podocarpus dacrydioides*), (i) adult and (ii) juvenile foliage;
c. lowland ribbonwood (*Plagianthus betulinus*), (i) juvenile leaf.

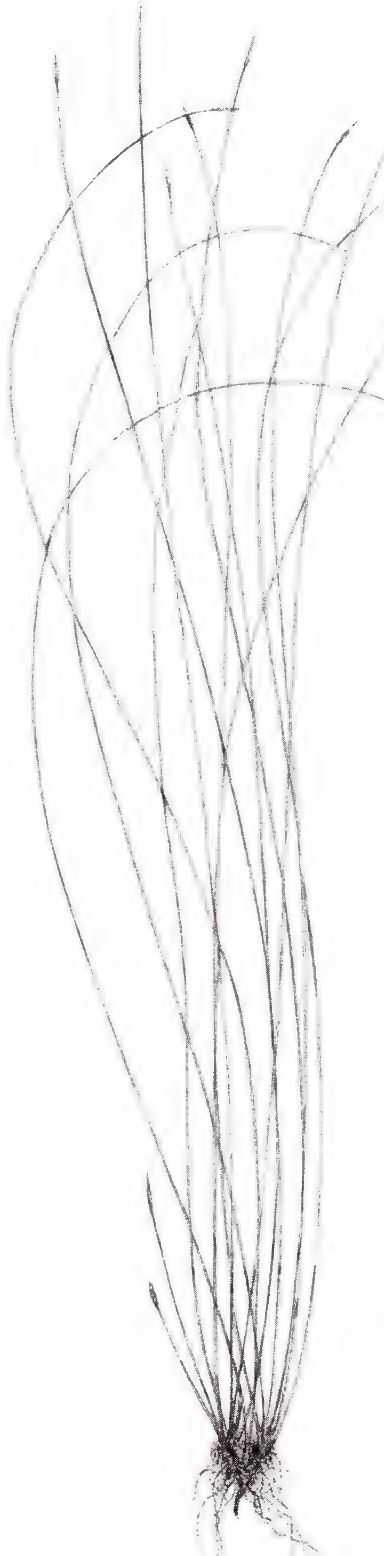
a

b

Fig. 30

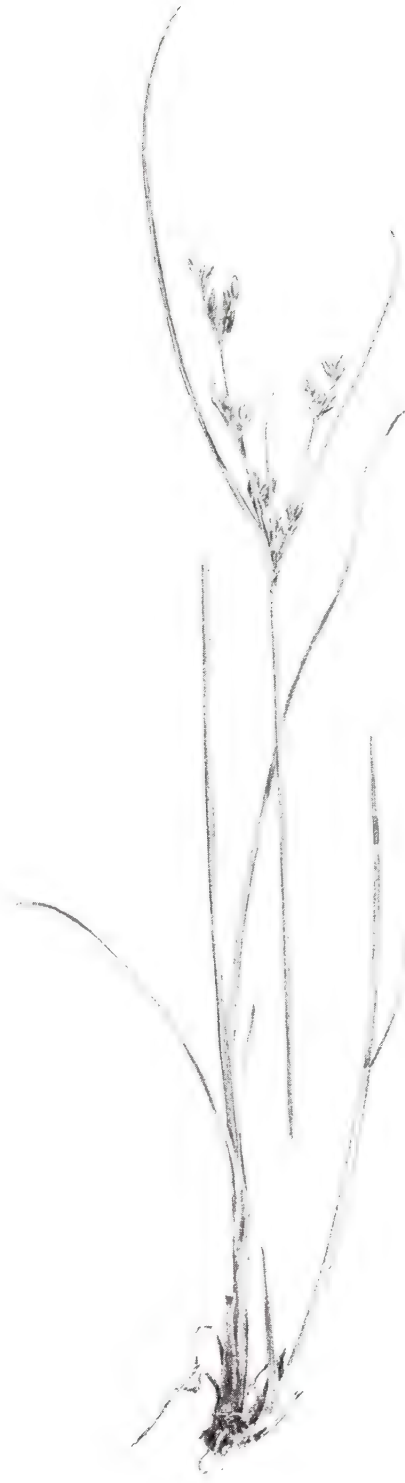
Species of river flats and wet land

a. kaikomako (*Pennantia corymbosa*), (i) juvenile and (ii) adult foliage;
b. *Galium palustre*, (i) flower x 10, (ii) section of stem x 10;
c. oxygen weed (*Elodea canadensis*);
d. buttercup (*Ranunculus repens*).



(i) x 2

(ii) x 5



b

a x 1/4

Fig. 31
Plants of wet land

a. *Eleocharis acuta* x 1/4, (i) spikelet x 2, (ii) stem with sheath x 5;
b. *Juncus tenuis*;
c. *Juncus articulatus*, (i) section along leaf x 5;
d. inflorescence of *Carex coriacea* x 1/3, (i) female and (ii) male spikelets;
e. *Lilaeopsis novae-zelandiae*, (i) leaf x 5.

4

Coastal vegetation

The coastline separates the two great realms of plant life, the one adapted to constant immersion in salt water, and the other being killed or damaged by salt water. There are three kinds of transition between these realms. The first is where steep rocky coasts give a relatively abrupt transition from sea to dry land, the second is where interplay of coastal currents, surf, and wind build up beach deposits of loose sand or gravel, and the third is where tidal lagoons form a gradual transition to fresh water or swamp habitats. In the first, there is a well-defined sequence, beginning with a rich and robust seaweed flora growing around low-tide level, where plants are seldom exposed to the dry air, yet light is optimal, and the water well aerated by wave action. Further up the shore, the sea life becomes sparser and smaller, to virtually cease at the high-water mark. This is a zone of stress, for the marine plants cannot tolerate the long exposure to the air, whilst periodic immersion in sea water precludes land plants. However, the hardy black lichen *Verrucaria* often encrusts the rocks just above high-tide level.

On sheltered shores, notably those of the south-western fiords, the rain forest often comes down to the level of the highest spring tides. More commonly, there is a zone where plants are subjected to spray, especially during storms. Where this is a regular occurrence, only specially adapted plants grow, many of which have succulent leaves or stems. Further back from the shore, a zone in which coastal species mingle with the most salt-tolerant of the inland species passes into the normal lowland vegetation. Here occasional salt-laden storms may damage sensitive foliage but too rarely to perceptibly influence the character of the vegetation.

In the vicinity of Westland National Park (Fig. 33-35), rocky shoreline vegetation is quite poorly developed. Loose gravel prevails in the inter-tidal zone, and this is too savagely ground by breakers to support plant life. Seaweeds grow only on the reefs of large boulders extending out from moraine headlands. Above high-water mark, the cliffs of gravel and boulders do not provide particularly stable footholds for vegetation, and the abundant rain washes away salts and thereby favours ordinary inland plants instead of typically coastal species. Wind-deformed trees of the lowland forest — kamahi (*Weinmannia racemosa*), rata (*Metrosideros umbellata*), rimu (*Dacrydium cupressinum*), and miro (*Podocarpus ferrugineus*) — come to the tops of the cliffs which are fringed by dense tangles of kiekie (*Freycinetia banksii*) and hedges of a white rata vine (*Metrosideros perforata*). The prevailing vegetation on the cliff faces is successional scrub of flax (*Phormium tenax*), akeake (*Olearia avicenniaefolia*), gorse (*Ulex europaeus*), and koromiko (*Hebe salicifolia*), and low, wind-shorn forest which is often dominated by mahoe (*Melicytus ramiflorus*). Several plants are

confined to this coastal forest (see p. 11). Further north, these all occur well inland, and it is the mild coastal temperatures rather than the influence of salt that confines them to the coast locally. Cliffs too steep or unstable to support woody vegetation are sparsely draped with a pendent grass (probably a form of *Poa anceps*) and, as on similar inland cliffs, sheets of *Blechnum capense* or *Gnaphalium trinerve*. Where fresh water trickles down there are green sheets of moss, *Gunnera monoica*, and an introduced chickweed (*Sagina procumbens*).

Close to the shore line, a true coastal shrub, *Hebe elliptica*, is abundant, and the commonest plant beneath it is often *Asplenium obtusatum*, a coastal fern with thick glossy leaves. On rocks exposed to spray, one can also find mats of a tiny filmy fern, *Hymenophyllum minimum*. On still more exposed places, the sea primrose (*Samolus repens*) is common. Other plants include *Lobelia anceps* and a rush-like sedge, *Scirpus nodosus*, but the succulent plants so characteristic of rocky coasts in less rainy climates, such as ice plant (*Disphyma*), *Suaeda novae-zelandiae*, and the chenopods or fat-hens, are not to be seen. A handsome sedge, *Cyperus ustulatus*, often grows near the bases of the cliffs.

Most of the shore line consists, not of cliffs rising directly from tide-washed cobble and boulder beaches, but of beach ridges of gravel brought down by the rivers or eroded from the cliffs. These have been thrown up by storm waves to form bars across river mouths and spits separating lagoons from the sea. For 4 km south of Hauraki Creek the coastal cliffs are also separated from the sea by beach ridges, which suggests either that sea level was once higher or that this part of the coast is still being uplifted from time to time. Active beach ridges support few plants, as they are still being worked by breakers during storms, but on their inland slopes there are likely to be stretches where some years have elapsed since disturbance. The vegetation that develops is usually dominated by gorse and flax. In some places, the ridges are capped by sand dunes built by the wind to above the reach of the highest surf. This unstable and somewhat saline habitat is first colonised almost exclusively by plants with rapidly growing rhizomes, i.e., pingao (*Desmoschoenus spiralis*), sand convolvulus (*Calystegia soldanella*), sand sedge (*Carex pumila*), and the introduced marram grass (*Ammophila arenaria*) which has become the most abundant.

Most beach ridges are eroding on their seaward margins and being driven over stabilised land or into lagoons on their inland side. However, on the Okarito Spit, at Gillespies Beach, and at some other localities, there are stabilised dunes and ridges lying behind the outermost and active one, and this is further evidence that there was a period when uplift of the land or retreat of the sea reversed the process of coastal erosion. Originally these stable areas supported mainly coastal, low forest on the ridges and swamps and salt marshes in the hollows, but a history of burning (doubtless extending back to early Maori habitation), sluicing and dredging for gold, and grazing by sheep and cattle have greatly modified the vegetation. However, areas not overgrown by gorse still support a rich assemblage of native and introduced plants.

Fig. 32 Bordering the dark, brackish water of Gillespies Lagoon there is a community of the shrub *Coprosma propinqua* and the jointed-rush *Leptocarpus similis*. This is separated from forest of rimu (*Dacrydium cupressinum*), kahikatea (*Podocarpus dacrydioides*), and silver pine (*Dacrydium colensoi*) by a narrow band of manuka (*Leptospermum scoparium*).

The coastal lagoons contain an array of plant communities depending on subtle gradients in wetness, tidal rise and fall, and salinity. On mud that is submerged most or all of the time, there are beds of eel grass (*Zostera muelleri*) near the lagoon outlets where the water is saltiest. Calmer, less brackish water has beds of *Ruppia*, a plant which pushes its fruit up to the surface on curious spiral threads and which is much browsed by water fowl; there are also the large green algae *Nitella* and the emergent reed *Scirpus lacustris*.

In most districts, lagoons include wide mud flats over which the tide ebbs and flows, but these are absent from South Westland, as is the characteristic estuarine plant, the succulent glasswort (*Salicornia*). Species occurring on the very limited patches of intertidal mud include a sedge (*Scirpus americanus*) with bluish-green stems sharply triangular in cross-section and the sea musk (*Mimulus repens*) which has light blue, yellow-centred flowers.

Instead of tidal flats, the South Westland lagoons have marginal flats, promontories, and islands which are up to 1 m above high tide level (Fig. 32). These seem to be remnants of old lagoon floors, left after tidal scouring has lowered the present floors to accord with present sea level. The dominant plant is jointed-rush (*Leptocarpus similis*) which is usually accompanied by two species of divaricating shrub, *Coprosma propinqua* and the shore ribbonwood (*Plagianthus divaricatus*). In places, especially where there is grazing, there is turf with such species as batchelor's buttons (*Cotula dioica*), *Dichondra brevifolia*, *Samolus repens*, *Selliera radicans*, *Scirpus subtilissimus*, and *Schoenus nitens*. Bog conditions develop a few metres back from the lagoon margins because of high organic content of the soil, leaching by rain, and sluggish drainage. The plant community is similar to those on inland bogs, excepting that species such as *Centrolepis ciliata*, wire-rush (*Calorophus minor*), and sundew (*Drosera binata*) are accompanied by coastal plants such as jointed-rush (usually rather stunted) and *Myriophyllum pedunculatum*. The inland extensions of the coastal lagoons contain almost fresh water, and the bordering vegetation is scarcely to be distinguished from the inland swamp described in the preceding chapter.

Fig. 33 **Habitat VII.** Okarito Bluff, a promontory of moraine, dominates a foreground of dunes. Plants illustrated are sand sedge (*Carex pumila*) in the right foreground, pingao (*Desmoschoenus spiralis*) prominent at left centre, and behind, an area of marram (*Ammophila arenaria*). The vegetation on the cliffs shows stages of development from nearly bare to dense scrub and low forest. Climax forest with podocarps extends back from the cliff tops.

Fig. 34
Coastal plants
a. *Asplenium obtusatum*;
b. *Dichondra brevifolia*, (i) detail x 2;
c. *Hymenophyllum minimum* x 10;
d. *Hebe elliptica*;
e. shore ribbonwood (*Plagianthus divaricatus*), (i) fruit x 5;
f. *Sagina procumbens*, (i) detail of shoot, (ii) seed capsule x 5.


(i) x 5
d
e
f
(ii) x 5
(i)


a x 1/5
(i)
b x 1/10
(i)
c

Fig. 35
Coastal plants ctd.
a. jointed rush (*Leptocarpus similis*) x 1/5, (i) seed head;
b. *Scirpus nodosus* x 1/10, (i) seed head;
c. *Samolus repens*;
d. *Carex solandri* x 1/4, (i) spikelets.

5

History of the plants and landscape

The origins

New Zealand is an old land with a young landscape — a paradox that is nowhere truer than in South Westland. Amongst the oldest sedimentary rocks are the greywackes which crop out near Lake Mapourika and in the Omoeroa Range; these probably date from the early Palaeozoic era, more than 500 million years ago (Table 1). Although laid down as sediments under the sea, they were derived by erosion of neighbouring land. This was the ancient continent of Gondwanaland, a single land mass made up of the present continents of Australia, Antarctica, South America, Africa, and India. The Southern Alps are composed of schist and greywacke laid down as sediments mostly during the Permian and Triassic periods, but they were thrust up into high mountains only during the last 5 million years and are thereby one of the youngest large mountain ranges in the world. Most of the surface features of the landscape, especially the mountain cirques and valleys and the lowland moraines and lakes, were moulded during the last major advance of the glaciers, which ended about 14 000 years ago. Coastal cliffs and lagoons, flat alluvial valley floors, and many other features are still younger.

The flora of New Zealand contains the same ingredients of age and youth. Fossil plants in Jurassic rocks represent vegetation unlike any living today, yet some of the plants are related, and possibly ancestral, to species still living in New Zealand. In particular, there were podocarps, a group which includes the modern rimu (*Dacrydium cupressinum*), totara (*Podocarpus totara*), matai (*P. spicatus*), and kahikatea (*P. dacrydioides*), and araucarians, a group which includes kauri (*Agathis australis*). Some living species may not have changed much since these times, especially among spore-bearing forms. A notable example is *Tmesipteris* (Fig. 9), an epiphyte on the trunks of tree ferns, which is usually classed as a psilophyte because of the absence of roots. This group is regarded as including the oldest land plants known, dating from the Silurian period.

From the middle of the Cretaceous period onwards, the fossil flora acquired an increasingly modern content. Most of the evidence is in the form of pollen grains which are singularly durable and have shapes and sculpturing diagnostic of the kinds of plants that produced them. Sedimentary rocks deposited near the end of the Cretaceous

Table 1 Geological periods and time scale

Era	Period	Millions of years before present
Quaternary	Post-glacial Pleistocene	0.014
Tertiary	Pliocene Miocene Oligocene Eocene	
		70
Mesozoic	Cretaceous Jurassic Triassic	
		230
Palaeozoic	Permian Carboniferous Devonian Silurian Ordovician Cambrian	
		600
Pre-cambrian		

period contain pollen grains indistinguishable from those of present-day rimu and silver beech (*Nothofagus menziesii*), and it is likely that by the beginning of the Pliocene period nearly the whole of the present lowland forest flora, or its immediate ancestors, were present in New Zealand. However, there were also many plants which no longer occur here, since the land had yet to experience the rigours of the ice age and the resulting decimation of the forest flora. Examples are palms of the coconut genus (*Cocos*), species of beech closely related to those still living in New Caledonia and New Guinea, and *Athrotaxis*, a coniferous genus now represented only by the Tasmanian King Billy pine and pencil pine. So far, none of the evidence for these Tertiary forests comes from the vicinity of Westland National Park, for the Tertiary rocks have been either eroded away or buried beneath moraine, except for a minute outcrop of Miocene mudstone near the mouth of the Omoeroa River. The nearest extensive terrestrial deposits rich in Tertiary plant remains are those which include the coal fields of North Westland. However, a test bore recently drilled on Waiho Beach has confirmed that 3600 m of Tertiary and more recent sediments overlie the greywacke basement there, as had been postulated by geologists.

It is currently thought that Gondwanaland separated into its constituent continents during the Jurassic period, the rifting which formed the Tasman Sea beginning some 80 million years ago. The distribution of some living plants reflects the Mesozoic land connections with South America, via a much warmer Antarctica where their fossil

relatives have been found. Notable examples are the beeches, podocarps related to totara and matai, and Winteraceae, a family of flowering plants with a very primitive structure which includes our horopito (*Pseudowintera colorata*). The relative proximity of Australia during the early part of the Tertiary era is reflected in closely similar forest floras in southern Australia and New Zealand at that time. Later in the Tertiary, the increasing aridity of the Australian continent destroyed most of the warm temperate forest there, until now the closest links are between three peripheral areas, Tasmania, New Zealand, and highland New Guinea.

While the fossil history of the lowland forest flora is reasonably well known, there is no fossil evidence concerning the origin of our mountain plants. This is because the latter usually become preserved only in mountain lakes and bogs as peat which is nearly always destroyed by subsequent erosion. Nevertheless we can make a few useful deductions. One is that the mountain flora is probably less than 5 million years old, if we accept that New Zealand was a warm temperate or subtropical archipelago which lacked mountainous country until the Southern Alps and other main ranges were thrust up. Another is that during the Quaternary, i.e., the era which extends from the beginning of severe cooling to the present, the climatic fluctuations, rapid evolution of the landscape, and continual formation of new habitats and destruction of old ones provided ideal conditions for rapid and continuing biological evolution. This is reflected in the large numbers of closely related species in genera such as *Hebe* and *Celmisia*. Some of these species are confined to small areas and there is frequent hybridism between species. Hybrids are even common enough between species that on the grounds of their shape and structure are considered to belong to different genera. This is especially true of the group of composites which includes the hard, cushion-forming raoulias or vegetable sheep, New Zealand edelweiss (*Leucogenes*), and some of the everlasting daisies (*Helichrysum* and *Gnaphalium*).

The ultimate origin of mountain plants is a matter for speculation. Some may have evolved from ancestors already present in New Zealand during the Tertiary era, for even during the warmest periods there must have been local habitats where plants requiring cool conditions could survive. For instance, silver beech and its near relatives in Patagonia, Tasmania, and eastern Australia all grow under cool, moist climates, yet their type of pollen has been present in New Zealand since the end of the Cretaceous period. Boggy uplands with very infertile soils are one kind of site where the ancestors of some mountain plants could have survived Tertiary warmth, and it is noteworthy that it is just this kind of site which supports many species of mountain plants near sea level in South Westland today. Other possible habitats include cliffs and cool ravines.

Much — or according to some authorities nearly all — of our mountain flora would have been derived from seeds or spores carried across the sea by wind or birds. One probable source was Antarctica before its vegetation, other than lichens and mosses, was extinguished beneath the ice cap. *Hectorella caespitosa*, a large cushion plant common at the upper limits of vegetation in the national park, may be such a refugee,

for its only relative *Lyallia* is confined to icy Kerguelen in the Indian Ocean. Tasmania seems to have carried a fragment of the mountain flora of Gondwanaland in its northern drift from Antarctica and, in turn, may have contributed seeds to the rising mountains of New Zealand via the prevailing westerly winds — a mode of arrival that is suggested by the recent discovery of a Tasmanian heath, ***Sprengelia incarnata***, in the south-west of Fiordland. An Australian origin is certain for some plants with wind-dispersed seeds, such as willow-herbs (***Epilobium***) and especially the orchids, a group in which most of our species are shared with Australia. The isolated mountains of south-east Asia, Indonesia, and New Guinea doubtless provided stepping stones for plants from the Northern Hemisphere. This is especially probable for species which are almost identical in Eurasia and New Zealand, for example, the swamp grass *Deschampsia caespitosa* and an alpine sedge, *Carex pyrenaica*.

The present landscape results from the interplay of two powerful processes; movements of the earth's crust on one hand and erosion and deposition on the other. In Westland, crustal movements are related to the Alpine Fault. Horizontal sliding along the fault caused a 450 km displacement of strata, so that the granites of Fiordland and the schists of Otago and Westland south-east of the Alpine Fault match the granites of Nelson and the schists of northern Marlborough. The rocks on both sides of the fault are rising, but the movement on the south-east side is far greater than that on the north-west and is estimated to have totalled some 18 000 m of vertical uplift since the early part of the Miocene period; this averages at 1 to 2 mm per year. Continuing horizontal movement has resulted in kinks in the valleys where they emerge from the mountains on to the low country north-west of the Alpine Fault. The vertical movement has formed the steep, landslide-scarred flanks of the outer ranges of the Alps. Other major faults west of the Alpine Fault and off-shore are known from geological and geographical evidence but do not show as surface features. Smaller faults criss-cross the mountains south-east of the Alpine Fault and are revealed as deep, narrow trenches or as belts of shattered, eroding rock.

Processes of erosion and deposition act even on the gentlest terrain, but in Westland they are of a magnitude hardly surpassed anywhere. Erosion has almost kept pace with the rise of the Southern Alps, so that they attain a maximum height of 3764 m instead of double the elevation of the Himalayas. During the Quaternary era, variously estimated to extend from 1 million to 3 million years back from the present, ice has been the most powerful agent eroding the mountains and either depositing the spoil as moraine on the lowlands or carrying it beyond the present coast. Water has been scarcely less effective, as witnessed by deep, narrow gorges cut in many valleys since the last major glacial retreat and by thick beds of gravel and silt deposited in former glacial valleys. On the geological time scale, the Quaternary era has been a time of extremely rapid oscillation between glacial and temperate climates; and the alternating glacial advances and recessions are so important in our story of landscape and vegetation that they must be recounted in some detail.

The ice ages

Most of our knowledge about the Quaternary era pertains to the last glacial advance and the succeeding period of warmer climate, known as the Holocene, which extends to the present day, for glaciation is so destructive that the most recent episode is apt to destroy the evidence for what has gone before. It is also difficult to assign a time scale to the earlier part of the Quaternary era, for while the events of the last 40 000 years or so can be dated by measuring the proportion of radio-active carbon in fossils such as wood, peat, and shells, and events that happened more than about 1 million years ago can be dated by other kinds of radioactivity, no really adequate dating methods have been devised for the period between.

Much of the Tertiary era in New Zealand was marked by rather slow sedimentation of limestone, mudstone, and coal measures, but as the mountains began to rise, they were eroded to yield more rapidly accumulating, coarser gravels. In North Westland, the deposits of the early Pleistocene mostly comprise the Old Man gravels which now form terraces 300 to 600 m higher than the present valley floors, and early Pleistocene glaciation is known from bouldery deposits at Ross. In South Westland, no deposits have been assigned to the first part of the Pleistocene period.

Good evidence for an alternation of cold glacial and warmer interglacial periods during the later part of the Pleistocene has also come from North Westland. During glacial episodes, great quantities of rock waste are carried out from the mountains to form large moraines, and melt-water rivers issuing from the glaciers build wide flood plains of gravel and silt downstream from the terminal moraines. During warmer periods between glaciations, the land becomes vegetated and the supply of gravel to the rivers is much reduced, so that the rivers tend to erode downwards and laterally, leaving the former flood plains as terraces and building new flood plains at a lower altitude. Sea levels fall by possibly as much as 200 m during glacial periods because so much water is extracted from the oceans and piled up as ice on land at high latitudes and altitudes, mainly in the Antarctic ice sheet. When climates ameliorate, sea level rises again. Since the land has also been rising in Westland during the Late Pleistocene, each interglacial period is represented by former sea cliffs and beach lines at successively lower elevations. Inland the old beach terraces merge into corresponding interglacial valley floors. This has enabled an elegant sequence of glacial and interglacial periods to be worked out for North Westland. The gold miners of the last century were well aware of the significance of these features, for they had discovered that the concentrations of auriferous black sand along the present beaches had their Pleistocene counterparts beneath elevated marine terraces.

The same sequence of glacial and interglacial episodes occurred in the vicinity of the national park, but because the Alps are higher and the coastal lowlands narrower, the ice of the last major glacial advance travelled beyond the present coastline and obliterated most of the earlier land forms. Nevertheless there is a great deal of late Pleistocene history to be unravelled in the area. At Cement Hill, near the mouth of the Omoeroa River, an old beach terrace has been lifted to 220 m above sea level. It is cut into older moraine and was mined last century for its auriferous black sand,

contained in beach gravels cemented hard by iron oxide — hence the name of this feature.

At the junction of Pug Creek and the Omoeroa River a bed of silt extends from 50 to 90 m above sea level. It is made up of thin but distinct layers of the kind formed when glacial melt water discharges into the still water of a lake or fiord. Each layer represents thawing conditions when the water is charged with silt, and the delineation between layers represents freezing periods when little or no silt is being discharged. The Pug Creek deposits were laid down in an inlet of the sea, probably at some depth, and the uplift of the land now causes them to be exposed above sea level.

Deep deposits of coarse gravels overlie the Pug Creek silts and extend southwards, forming a rolling plateau (now dissected by deep gorges) which is about 300 m above sea level at its seaward margin. The basal layer is coarse enough to be regarded as moraine, and most of the upper 100 m was also deposited by ice and shows on the present surface as long moraine ridges. Wherever the intermediate layers are revealed in slips and cliffs, however, they consist of finer, river-deposited gravels.

It may have been at the end of this alluvial phase that the sea cut a cliff in the plateau, and this can still be traced for 12 km southwards from Cement Hill. The terraces at the base of the cliff are 60 to 100 m above present sea level, but the original shore seems to have been buried under later gravels and moraine. A layer of sand exposed between 6 and 15 m above the beach in the present coastal cliff at Waihapi Creek may give a better idea of the old sea level (Fig. 36). Seventy kilometres further north along the coast, near Harihari, a thick layer of peat containing pollen of lowland forest species developed and is now sandwiched between preceding and succeeding glacial deposits exposed in the modern cliff. The evidence for a high sea level and forest vegetation probably denotes the last interglacial period, when the climate was at least as warm as at present.

The following, most recent, major glaciation is the one which has so strongly moulded the landscape and vegetation we see now. Even this glaciation, known as the Otiran, was not a single cycle of advance and retreat, for the cold period was interrupted by comparatively warm intervals. In North Westland, several distinct glacial episodes or **stadials** and warmer **interstadials** have been recognised, but in South Westland, the best division that can be made in the light of present knowledge is into an older **Piedmont** advance and a younger **Valley** advance. These were separated by at least one interstadial, for the older surfaces on the piedmont appear to have developed mature soils, implying existence of continuous vegetation, which were later partly eroded under conditions of renewed severity.

During the Piedmont advance, the ice spread in a northerly direction across the lowlands as broad, relatively shallow lobes, leaving complex loops of moraine. Subsequently, the glaciers straightened and deepened their valleys, so that by the final major advance most of the ice was concentrated in deep troughs which followed the shortest routes from the mountains to the sea (Fig. 41). Evidence from radio-carbon

Fig. 36 A 30 m-high coastal cliff near Waihapi Creek. The bottom layer of gravel, immediately above the cobble beach, is cemented outwash gravel and moraine dating back to an early glaciation. Following this, there was a warm interglacial period when the sea deposited the stratum of sand; uplift of the coastline has lifted this above present sea level. The uppermost gravel bed relates to the last glaciation. Its lower portion is quite fine textured and has obviously been deposited by a river, but towards the top of the cliff the boulders are much larger, indicating the approach of the ice. Probably, however, the glacier never came closer than 600 m at this point.

The vegetation on the cliff is mainly ***Phormium tenax***, akeake (*Olearia avicenniaefolia*), and a hanging grass, ***Poa*** cf. ***anceps***. Espalier-like rata vine (*Metrosideros perforata*) caps the cliff tops, and, at the left, there are wind-swept podocarp trees.

Fig. 37 Opposite
A sharply defined upper limit of silver beech (*Nothofagus menziesii*) forest lies at 1050 m in the Landsborough Valley. Above this, open scrub grades into snow tussock grassland and thence into high alpine barrens. The peak on the left is Mt. Clarke (2450 m). There is permanent snow on its flanks, and the cirque basin below has moraines which probably were formed within the last 300 years. The central peak, Mt. Ward (2644 m), shows a small icefield on its north-western face. Below 1500 m, parallel ice lines from the great glacier that once filled the Landsborough Valley cross the slopes. The rugged, eroding gullies on the left of the view begin on the lower side of a fault-scarp.

dated peat and wood from several parts of Westland shows that they had begun their retreat 14 000 years ago.

During glaciation, ice eroded cirques on the southern and eastern sides of peaks and ridges as low as 1400 m above sea level (Fig. 42) — compared with 2100 m which is the height of the lowest peaks that carry icefields at present. The major icefields near the main divide may not have been much thicker than at present, but the valleys were full of ice which flowed towards the coast as huge glacier tongues. The levels at the surfaces of these glaciers can be traced from old **ice lines** preserved on the mountain sides in a few places. These ice lines consist either of moraine fallen from the edge of the glacier, or of **kame terraces** deposited by water or landslides against the glacier. On the western side of the Southern Alps ice lines are poorly developed compared with those of the broad, glacially sculptured valleys east of the main divide, although there are fine examples in the middle reaches of the Landsborough Valley, where they consist of series of terraces representing, as it were, tide marks as the glacier shrank, with the highest at 1500 m above sea level (Fig. 37). There are also prominent ice lines at 1200 m above sea level on the Burster Range above the junction of the Spencer and Callery Valleys and along the Chancellor Shelf above the Fox Glacier. Where the glaciers crossed the Alpine Fault, their surfaces were between 600 and 700 m above sea level.

North-west of the Alpine Fault, lateral moraines indicate the height of the ice; the most striking is that formed on the southern flank of the Waiho Valley during the Valley advance. It begins at 400 m above sea level and describes a remarkably straight

line which slopes seaward along the flanks of the Omoeroa Range, to end only 45 m above sea level at the Omoeroa Bluff.

On the inner ranges of the Alps, precipitous rocks on peaks projecting above the ice fields would have been ice free, but they could have offered no refuge to plant life as they are above the present limits of nearly all plants other than lichens. The outer ranges, on the other hand, projected well above the glacier surfaces, and, because of their relatively low altitude, they carried little ice other than that issuing from cirques on their leeward slopes. Their ice-free slopes and ridges experienced a **periglacial** climate, characterised by prolonged winter snow and short summers with daily cycles of freeze and thaw. Under these conditions, rock is subjected to intense frost-shattering. After snow melts in the spring, any soil that exists becomes a saturated, porridgy mass liable to flow down slope under the influence of alternate freezing and thawing. Despite the rigours, periglacial landscapes support scattered higher plants. At present, such conditions are usual in the national park above 1700 to 1800 m above sea level, and extend down to 1300 m in shaded gullies where snow persists into summer. During the Otiran glaciation, it is likely that periglacial conditions prevailed on ice-free areas almost down to present sea level. Nevertheless, there appear to have been areas where grassland, bog, and scrub existed, mainly on unglaciated parts of the lowlands, including land exposed by the fall in sea level. Plant remains in the moraine at Omoeroa Bluff (which possibly grew under a climate that was already becoming warmer) include pollen mainly of composites, grasses, *Coprosma*, and sedges, as well as wood of *Hebe*, composites, and *Pseudopanax* (probably *P. colensoi* or three-finger). North of the Whataroa River mouth, wood is present in peat that was buried in glacial lake deposits nearly 17 000 years ago, although most of the pollen was derived from grasses.

Forest is unlikely to have survived in the vicinity of the national park, but there is little doubt that it survived in favoured areas north and south of the main glaciers. No absolute proof of this has yet been found in the fossil record, but the distribution of plants today, especially the beeches (*Nothofagus*), demands such survival. The small stand of silver beech on Mt. Arthur, a mound of Tertiary rock that projects through moraine on the south side of the Mahitahi River, could well be descended from trees surviving there during the Otiran glaciation, and there were undoubtedly other pockets in the hills between Paringa and Haast.

The last 14 000 years

Fourteen thousand years is time immemorial in the usual reckonings of men but an almost infinitesimal slice of geological history. Though changes in the physical landscape have been comparatively minor, the period is exceedingly important biologically, especially in regions such as Westland which had experienced severe glaciation, because nearly all the present mantle of soil and vegetation has developed during it. At the height of the Valley advance, ice covered perhaps 70 percent of the area. Most of the

rest was periglacial, with only scattered plants. Possibly only 5 to 10 percent of the land was covered by continuous vegetation which at its tallest would have been scrub of subalpine character.

As the climate became warmer, the snow line retreated up the mountain sides, and the supply of ice became insufficient to maintain the flow across the lowlands. The ice in the valleys therefore became stagnant and gradually melted, although the quantity had been so great that masses of "dead" ice must have lingered for hundreds or even thousands of years (even as buried masses of ice persist in the Fox Valley today, 40 years after they were stranded by glacial retreat). North-west of the Alpine Fault, the disappearance of the ice from the major valleys left temporary lakes, which later filled with river sediments; thus arose the flats of the Karangarua, Cook, and Waiho Valleys. Unfilled lobes of the glacial valleys remain as Lakes Matheson, Mapourika, and Wahapo, while up on the morainic hills, shallow lakes such as Gault and Mueller occupy depressions formed during the earlier Piedmont advance. In places, small masses of ice were stranded to leave depressions after melting. Such **kettleholes** are likely to become filled very slowly with peat and mud, and the pollen trapped in successive layers has been sampled and identified to provide a picture of the gradually changing vegetation.

In the mountains, erosion (especially at high altitudes) and burial (especially on lower slopes and in the valleys) have modified the glacial landforms to a much greater extent than on the lowlands. Although the broad outlines of glacial sculpturing remain, there are relatively few places where the surface details persist; the two main areas are the broad summits of the Fox and Copland Ranges, where the old cirques and moraines are still obvious, and the slopes rising from the southern bank of the Karangarua River in its upper reaches, where only thin soil and sparse vegetation have developed on ice-scoured rock (Fig. 38).

Where glaciers gouged deep hollows in the mountain valleys, these also have been filled with alluvial gravel and silt to form river flats (Fig. 39). Such flats are extensive along the Landsborough River, but uncommon elsewhere. Cassel Flat and Welcome Flat in the catchment of the Karangarua River are the largest outside the Landsborough Valley; here gravel built up behind bouldery fans blocking the valleys, and the rivers subsequently carved out terraces and the present flats. The prevailing tendency of rivers in the Westland mountains, however, is not to deposit alluvium, but to cut gorges, so that the original glacial valley floor or the moraine stranded by the disappearing glaciers are left as terraces. At the Alpine Fault, continuing uplift and downcutting has raised such terraces 50 to 120 m above present river level.

In wide valleys like the Landsborough the receding glaciers deposited moraine on the mountain slopes, but most of the mountain valleys in Westland National Park are so narrow, their gradients so steep, and their sides so precipitous that little moraine has remained on the slopes. Instead, it chokes the beds of the rivers which have long reaches where the water cascades wildly over huge moraine boulders. Commonly in

Fig. 38 In the upper reaches of the Karangarua River, ice pared the flanks of Bare Rocky Range down to bedrock. Scrub of stunted manuka (*Leptospermum scoparium*), pink and silver pines (*Dacrydium biforme, D. colensoi*), rata (*Metrosideros umbellata*) and silver beech (*Nothofagus menziesii*) now clothe the gentle slopes in the foreground at 750 m, but the steep slopes below the mist-shrouded summit of McGloin Peak (2070 m) are almost devoid of vegetation.

Fig. 39 In the glacially carved valley of Architect Creek, a depression has been filled by gravel, to form low flat terraces which support grassland at an altitude of 560 m. Behind the flat, kaikawaka (*Libocedrus bidwillii*) forest occupies a mound of moraine on the right, and low forest mainly of mountain holly (*Olearia ilicifolia*) and mountain ribbonwood (*Hoheria glabrata*) grows on immature soil on the fan on the left.

these steep valleys, downcutting of the beds is offset by material moving downwards from the valley sides. Evidence of talus, moraine, and even bedrock continuously sliding downwards is seen in tilted trees and numerous slips. Even whole mountain sides are collapsing where the melting of glaciers has removed their support. Deep fissures, particularly along ridge crests, indicate the early stages of collapse in several localities; but on the Burton Range, massive slumping of the southern slopes has left a landscape reminiscent of limestone sinkholes along the crest. In the Fox Valley also, valley walls are collapsing, partly as a consequence of glacial retreat during recent decades. The Douglas River, in its middle reaches, enters an awesome chasm, where opposite walls meet through sliding of the northern valley slope.

Frequently, landslides block rivers with great fans of broken rock. For example, in the bed of the Karangarua River, upstream from McTaggart Creek, a landslide buried a mature forest 360 years ago under 33 m of rock and gravel, and the river has subsequently cut down again to expose the standing trunks. As recently as 1976, the same river was dammed by a large landslide, just downstream from its confluence with the Troyte. Rivers have also been blocked by resurgent glaciers and their moraines.

At the coast, land exposed by the glacial lowering of sea level was inundated again as the ice melted from high altitudes and high latitudes throughout the world. Cliffs were cut at exposed parts of the new shore line and the seaward extensions of moraines were reduced to reefs of boulders. Embayments were impounded by sand and gravel spits to form lagoons. Subsequently, sea levels relative to the adjoining land seem to have fallen a little, leaving the stranded cliffs, dunes, and former lagoon beds mentioned on p. 87. Recently, however, the sea has been eroding the coastline throughout this part of Westland, destroying lagoon barriers, and at several points washing out buried kahikatea forests, two of which have a radiocarbon age of about 3500 years.

Clothing of the land by plants after retreat of the ice was a complex process, varying from place to place according to local conditions of soil and climate. During the early post-glacial times, grassland still prevailed on the piedmont areas, and this was followed by vegetation in which the shrubs *Coprosma* and *Myrsine* were prominent. Presence of pollen of composites, *Libocedrus*, and *Cyathea* (probably *C. colensoi*, the prostrate "tree" fern) suggests that this vegetation was scrub and forest similar to that now prevailing at about 800 to 1000 m. About 9200 years ago, kamahi suddenly became dominant in the pollen record and was followed quickly by preponderance of rimu pollen, indicating that climate and vegetation had become similar to those of today.

Indirect evidence of plant succession after deglaciation can be drawn from the development of vegetation on moraines and other land surfaces formed during more recent advances and retreats of the glaciers. This is especially useful at higher altitudes, where no direct fossil evidence has so far been found. There are, however, two important differences. One is that plant successions during the first few thousand years took place in a gradually warming climate with altitudinal belts of vegetation moving uphill, until the scrub and grassland that occupied ice-free coastal hills became established in

their present position above the forest limits. Thus a post-glacial succession which began with plants now found at 1000 m could culminate in lowland forest.

The second difference is that at the beginning of post-glacial time there was only a small flora composed of species which had managed to survive the glaciation of the area. These were gradually augmented by species spreading in from areas where richer floras had survived. This spread is apparently still occurring, for a number of species have geographic limits in or near Westland National Park which are unrelated to existing environmental barriers. The lowland forest species probably had to spread from survival areas as far away as the northern tip of the South Island; some species may have not survived closer than Auckland province. Those probably still extending their ranges southwards include toro (*Myrsine salicina*, Fig. 5), for which Mapourika Hill is the southernmost known occurrence; *Alseuosmia pusilla*, which reaches the Arawhata district; hinau (*Elaeocarpus dentatus*, Fig. 4), for which the southernmost verified locality is the southern end of the Copland Range; and Westland quintinia (*Quintinia acutifolia*) and New Zealand calceolaria (*Jovellana repens*) which occur south to the Karangarua River.

Silver beech (*Nothofagus menziesii*), on the other hand, came into the park from survival areas in the south. Apparently, it reached the middle reaches of the Landsborough Valley not much earlier than 1000 B.C. and probably entered the Karangarua Valley even later. One must go 35 km further south to see the red-flowered mistletoes *Elytranthe* that parasitise beech trees. The spread of beech in the Karangarua Valley may reveal much about how beech forest recovered after the Otiran glaciation. It occurs mainly between the Troyte confluence and the Cataracts. The slopes to the south of this reach were scraped bare by ice and now support stunted forest, scrub, and boggy openings (p. 54). Beech has spread through this, to as high as 550 vertical metres above the river (1040 m above sea level). On the slopes to the north, a shattered, deeply weathering substratum supports vigorous low forest of mountain ribbonwood (*Hoheria glabrata*) and other trees. Here, beech seedlings become established sporadically on eroding banks along the river and its tributaries. Those that succeed eventually overtop and suppress the smaller competing species and shelter their own progeny instead. In this way, discrete groves of silver beech have developed on the north bank, mostly within 30 m of the river. In addition, trees and small stands are scattered downstream as far as Cassel Flat. There is also an isolated clump at the head of the Karangarua Valley, which demonstrates that the rather heavy seed can be carried by wind (or birds) for at least 3.5 km.

Even subalpine and alpine plants suffered much extinction during the glaciation. The following species characteristic of western Otago and Southland now may be moving northwards: *Ranunculus buchananii*, *Raoulia buchananii*, and *Celmisia hectori* (Fig. 50) which have their northern limits on the mountain range separating the Douglas and Karangarua Rivers; a robust species of *Forstera* which has its northernmost known limit on Mt. Fox; *Dracophyllum menziesii* with its northern limit on the Fox Range; and the striking *D. fiordense* (Fig. 15) with its limit on Alex Knob.

No alpine species are known to have their southern limit in Westland National Park, although three are near the southern end of their range. These are the large, yellow-flowered buttercup *Ranunculus godleyanus* which extends to the Fox Glacier and to a little further south in Mount Cook National Park, and *Carex libera* and *Drapetes multiflorus* which reach Mount Aspiring National Park. *Euphrasia zelandica* (Fig. 47), the commonest of several kinds of eyebright in the park, occurs in subalpine grassland almost throughout New Zealand. In the west of the South Island, it is accompanied by the very similar *E. cockayniana* to at least as far south as Arthur's Pass. The flowers of both species have yellow throats, but the first species has white petal lobes, and in the second the petal lobes are yellow as well. On Alex Knob and Mt. Fox some plants which otherwise fit *E. zelandica* have yellow flowers. This suggests that although *E. cockayniana* has not spread as far south as the park, the genes for yellow petal lobes have been able to do so as a result of the species hybridising where they overlap.

A better-documented example of the results of hybridism is seen in the totara (*Podocarpus totara* var. *waihoensis*) which occupies the lowland river flats. This belongs to the same species as the true totara occurring on similar sites in other parts of New Zealand, but it is smaller in stature and has narrower leaves. It seems that before it could occupy the lowlands of South and Central Westland after the ice age, it had to spread across valleys in the Buller district and North Westland which were already occupied by a shrubby totara (*Podocarpus acutifolius*) with very narrow, sharp leaves. While so doing it crossed with the latter and became "contaminated" with some of its genes.

Some species seem to have come into South Westland from the eastern side of the Alps, especially into the Landsborough Valley which is drier than other Westland valleys and linked with the Mackenzie Country via 1600-m high, ice-free Brodrick Pass. Examples are the little chickweed *Stellaria gracilenta* (Fig. 27), a high alpine composite (*Haastia sinclairii*), and blue wheatgrass (*Agropyron scabrum*) which also occurs in a few places in the Karangarua Valley system.

Incomplete recovery from ice-age losses is reflected in the absence of many plants which might, from their habitat preferences, be expected to thrive in the park. There are no whipcord hebes, very few species of bidibid (*Acaena*) or batchelor's buttons (*Cotula*), and only one known occurrence of a vegetable sheep. Only one of the four species of beech is present, and even this occurs only in the southern corner of the park.

The severe environments presented by Westland in geologically recent times are reflected also in the absence of any species restricted to the region, i.e., **endemics**. In this respect, Westland contrasts strongly with western Nelson and Fiordland, where there are many endemic plants, some of which are confined to very small areas. However, a few species occur only in Westland and the immediately adjacent mountains on the Canterbury side of the Main Divide. These include *Ranunculus godleyanus*, the most southern representative of a closely interrelated group of buttercup species which

extend as far north as Mt. Hikurangi near East Cape, and *Hebe treadwellii* which is very closely related to *H. pinguifolia* of Canterbury and Marlborough.

The Little Ice Age

The retreat of the glaciers has not been uninterrupted. On several occasions ice advanced, to leave substantial moraines down-valley from the present glacier terminals. One such moraine is the Waiho Loop, the prominent, forest-clad ridge which forms an arc across the pasture land of the Waiho Valley 4 km north-west of Franz Josef township. When the Franz Josef Glacier advanced over Canavan Knob towards this terminal, it overwhelmed a rata tree which was subsequently exhumed during quarrying, and radiocarbon dated as 11 450 years old. Another radiocarbon date indicates that a moraine closer to the Franz Josef Glacier is about 5000 years old. Moraines also occur down-valley from the La Perouse, Strauchon, Horace Walker, McKerrow, Spence, and Fettes Glaciers, and some of these can be related to glacial advances dated at 5000, 2500, and 1500 years ago.

The most recent phase of glacial activity culminated in advances in about A.D. 1600, 1750, and 1830 which left prominent moraines below the terminal faces of nearly all the existing glaciers (Fig. 40). These moraines have been dated by counting the annual growth rings of trees which have colonised them. The ice has gradually receded

Fig. 40 Crests of two moraines are highlighted by lines of rata (*Metrosideros umbellata*) trees, in the Waiho Valley downstream from the Franz Josef Glacier. The upper crest represents a glacial advance about 1750, and the lower crest, an advance about 1830. The tall shrubs in the foreground are akeake (*Olearia avicenniaefolia*). Behind the moraines, there is forest with crowns badly damaged by opossums.

since the nineteenth century maximum, and the recession has been particularly rapid during the last few decades. Nevertheless, minor advances occurred between 1890 and 1910 and in the 1930s, early 1950s, and mid 1960s. In Europe, there were similar advances between the seventeenth and nineteenth centuries. This period has been referred to as the "Little Ice Age", and it was a time of stormy weather with cold winters and cloudy summers. The minor advances of the Franz Josef Glacier since 1894 have been correlated with heavier-than-average winter snowfall 3 to 5 years earlier. Wasting of glaciers is also retarded during cool, cloudy summers.

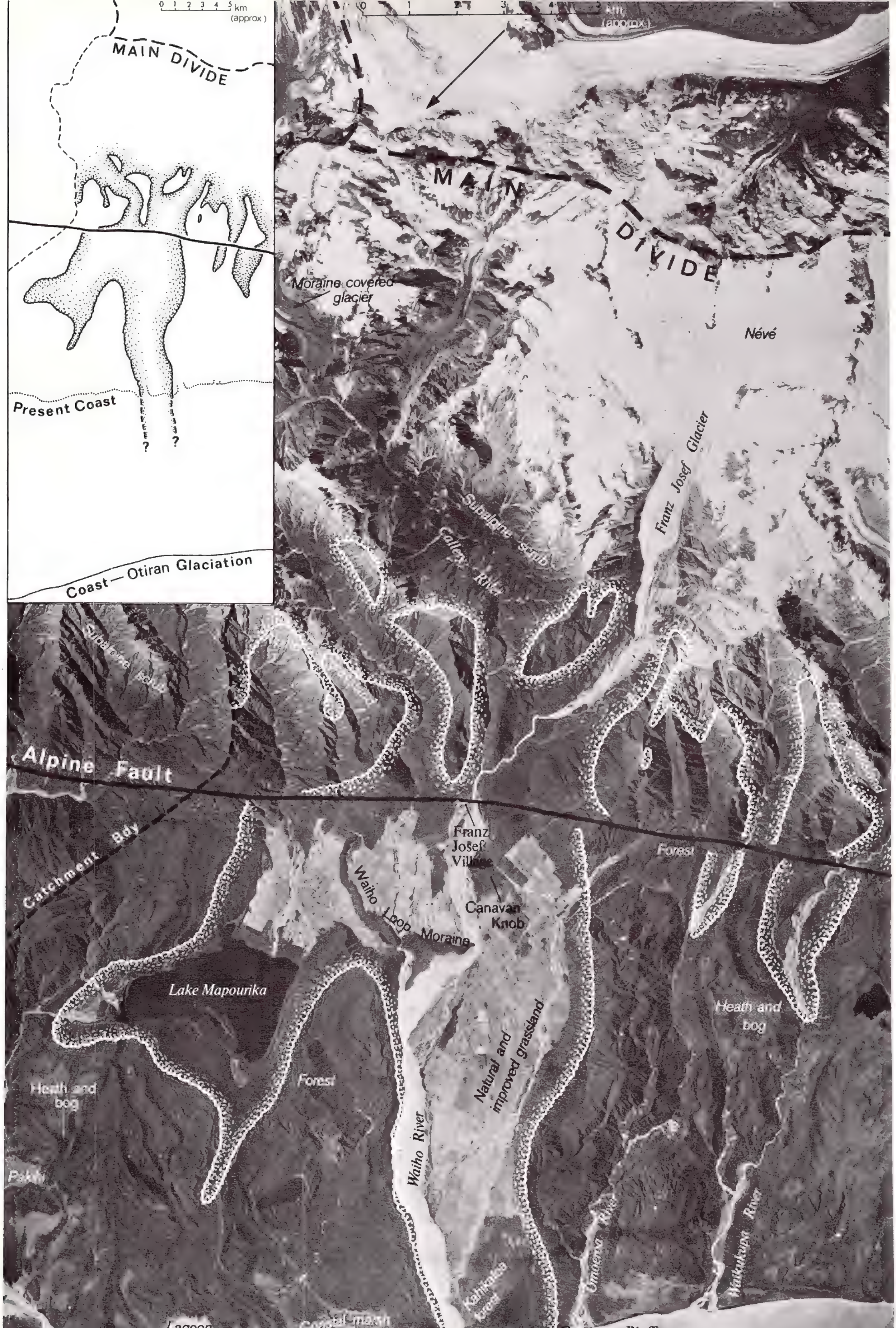
Botanical evidence that heavy snowfalls are a major factor in our Little Ice Age comes from timberline in the Landsborough Valley in places where snow prevents forest from reaching its maximum altitude. Here silver beech trees in the uppermost forest are mostly severely stunted and malformed by snow, but there are also huge veteran beech trees, twice the height of their neighbours, with erect trunks up to 2 m in diameter. Some grow among the stunted trees, while others stand out in the meadows. Such trees are at least 450 years old and clearly pre-date the seventeenth century glacial advance. In the meadows and scrub beyond the margins of the stunted forest there are scattered saplings and seedlings of beech, well established but less than 50 years old. Therefore, three climatic periods seem to be represented. Before the glacial advances, snowfalls were relatively light, which allowed trees to grow upright. Trees established during the period of glacial advances were stunted by snow, and areas of forest were destroyed by avalanches. Finally, decreasing snowfall has allowed erect limbs to grow from malformed trees during the last 100 years and has enabled establishment of young beech trees beyond the forest margins during the last 50 years. On less snowy sites, beech trees ascend to about 1050 m, a limit which is determined by summer temperature, and, on these sites, no evidence of comparable events has been detected. This suggests that changes of temperature may not have been as important in recent variations of our glaciers as changes in precipitation.

Contemporary with the resurgence of the glaciers, there was a reduced rate of regeneration among most of the forest conifers, so that today stands of rimu (*Dacrydium cupressinum*), matai (*Podocarpus spicatus*), and kaikawaka (*Libocedrus bidwillii*) often have a disproportionate number of mature trees older than 400 years and a corresponding deficit of young trees, particularly among those which would have been seedlings during the 1600 to 1800 period. Thus, though kaikawaka is vigorous on terraces on the floors of frosty valleys, in its main habitat at the upper limits of the forest most of the trees are dead. There are usually all size classes of rimu on poorly drained, infertile sites on old glacial terraces, but on hill sides and the lower slopes of the mountains it is represented mainly by large trees. Young plants of matai are rare almost everywhere. By way of contrast, the tree totaras (*Podocarpus totara* and *P. hallii*) and miro (*P. ferrugineus*) are usually well represented by young plants.

The anomalous regeneration rates were usually explained in terms of climatic change, even before the remarkable coincidence with glacial variations was fully appreciated. If the two kinds of event really had the same climatic cause and were not merely coincidental, it suggests that the seventeenth and eighteenth centuries were charac-

terised by persistent westerly weather, with prolonged cloud and rain and heavy snow on the névés. Under such conditions, production of seed by conifers would decrease,. and there would be less chance of seedlings becoming established where light was a critical factor — as in the subalpine fog belt in the case of kaikawaka, and in forests with a dense ground cover of ferns in the case of rimu. It may be noted that matai now regenerates far more prolifically in the warm valleys of Nelson and Marlborough than in Westland. However, this is only a tentative explanation, and other explanations have been offered. Possibly, faunal changes which accompanied the arrival of man in New Zealand were responsible; kiore (*Rattus exulans*) might have selectively destroyed seed, or the disappearance of moas might have led to denser undergrowth which smothered seedlings of native conifers. The Maoris could have introduced soil-inhabiting plant diseases with their food plants; the *Phytophthora* fungus which at present kills young trees of kauri (*Agathis australis*) in the Auckland district is possibly an example.

Fig. 41 Opposite
Aerial photograph of the Waiho River catchment from an altitude of 5000 m, showing present features and vegetation, position of the Alpine Fault, and extent of ice during the last major advance of the Otiran glaciation. The inset indicates the approximate extent of dry land exposed by ice-age lowering of sea level.



0 1 2 3 4 5 km (approx)
MAIN DIVIDE
Present Coast
?
?
Coast — Otiran Glaciation
0 1 2 3 4 5 km (approx)
MAIN DIVIDE
Moraine covered glacier
Névé
Franz Josef Glacier
Subalpine scrub
Callery River
Alpine Fault
Catchment Bdy
Franz Josef Village
Canavan Knob
Waiho Loop Moraine
Forest
Lake Mapourika
Heath and bog
Forest
Natural and improved grassland
Heath and bog
Waiho River
Lagoon
Omoeroa Bluff

Fig. 42 On the south side of the Fox Range, Pleistocene ice carved this large cirque. The skyline ridge has an altitude around 1350 m, and the floor, bounded by the low moraine in the foreground, lies at 1180 m. Today, one would need to climb about 800 m higher to find icefields capable of carving such basins. Dense grassland of snow tussock (*Chionochloa pallens*) clothes almost the whole basin, but on knolls and spurs there are clumps of turpentine scrub (*Dracophyllum uniflorum*).

6

The changing vegetation

Although the Maoris doubtless influenced the vegetation here and there in Westland during 900 years of occupation, large-scale alterations began only with the coming of the Europeans. The changes range from replacement of one community of native plants by another following damage by fire or introduced browsing animals, to complete destruction of the native vegetation and its replacement by species of man's choice – or by biological deserts of asphalt and concrete.

Deliberate clearing

Over the greater part of lowland New Zealand, the original vegetation has been completely destroyed by felling, burning, and ploughing, and by earth-moving machinery in more recent land "development". Native plants survive mainly where the land is too rugged or infertile to be worth the effort of clearing and cultivating. Even in South Westland, most of the mixed forest of totara (*Podocarpus totara*), matai (*P. spicatus*), and kahikatea (*P. dacrydioides*) has gone from the fertile river flats. The largest forest tracts remaining in the valleys are the magnificent pure stands of kahikatea near the mouths of the major valleys, but these are disappearing at an alarming rate, partly through clearing, and partly through natural changes in river courses, for in the long term kahikatea forest is essentially a temporary community.

To a rather limited extent, conventional pastures of ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*) have been sown, but more commonly, rough pastures of such grasses as tall fescue (*Festuca arundinacea*) and Yorkshire fog (*Holcus lanatus*) have become established with minimal help from the farmer after the forest has been subdued by axe, chain saw, and fire. Weeds are very persistent, as it is difficult to maintain pastures of the quality that can be achieved in districts with higher natural fertility and readier access to fertilisers. The buttercup *Ranunculus repens* (Fig. 30) is invariably conspicuous in Westland pastures, together with both native and introduced sedges and rushes. There is also a strong tendency for shrubs, especially coprosmas and even young trees of totara to spring up wherever there is a respite from grazing and trampling, as along fences, on steep banks, and among piles of logs. On some swampy areas where attempts to establish pasture have failed, there are now promising young groves of kahikatea.

On lawns, the original sown grasses can be replaced almost completely by native mat-forming plants, especially *Pratia angulata*, easily distinguishable by its small white

flower split down one side, *Hydrocotyle novae-zelandiae*, a plant with round leaves and inconspicuous umbels of small green flowers, and batchelor's buttons (*Cotula squalida*).

In contrast, certain ornamentals persist many years after gardens have been abandoned. The tall, lush, purple-flowered *Impatiens glandulifera* is common on waste land around Franz Josef village and a few other places, while clumps of *Hydrangea* are among the few signs of former habitation at Three Mile and Five Mile. One ornamental, the blue-flowered Himalayan pea (*Parochetus communis*), has spread along the verges of the glacier access roads, while the orange-red-flowered hybrid montbretia (*Crocosmia* x *crocosmiifolia*, of the iris family) multiplies successfully through transport of its corms by earth-moving machinery.

Introduced species

New Zealand has many examples of native vegetation being invaded and partly or completely replaced by introduced plants, usually after it has been damaged by fire or grazing. This has not happened with the South Westland forest; even after logging, the damage is repaired by native plants unless the forest itself is cleared. Swamp vegetation, however, has been invaded by several common introduced species which spread along the waterways, especially the creeping rush *Juncus articulatus* (Fig. 31) and *Galium palustre* (Fig. 30) which produces spangles of tiny white flowers. There are also two buttercups, *Ranunculus repens* and *R. flammula*, and a forget-me-not (*Myosotis caespitosa*).

Probably the most modified vegetation is the successional grassland of the river flats and coastal dunes, which Haast described in 1865 as fine grazing. Today, these grasslands still exist, but they consist of browntop (*Agrostis tenuis*), Chewing's fescue (*Festuca rubra*), Yorkshire fog, and other "English" grasses and weeds. In places, there is serious incursion by gorse (*Ulex europaeus*), and, locally, blackberry (*Rubus fruticosus*). There are some conspicuous tussocky, unpalatable native plants, chiefly silver tussock (*Poa laevis*) and species of *Uncinia* and *Carex*; one of the sedges, *Carex testacea*, is remarkable for the 2-m long, thread-like stalks that carry the seed heads. Close inspection of the grassland reveals numerous small plants, e.g., the hairy-leaved *Nertera setulosa*, the little prickly heath *Cyathodes fraseri*, the white-flowered hebe-like little shrub *Pimelea prostrata*, the small, green-flowered, onion-leaved orchid *Microtis unifolia*, and loose tangles of *Coprosma brunnea* and *Pernettya macrostigma*, the female plants of the former bejewelled with bright blue berries in autumn (Fig. 27-28). Our smallest lawyer, *Rubus parvus*, grows locally on the slopes of terraces. Its stems are underground rhizomes, but the starry white flowers and large red berries are quite conspicuous. One can surmise that the native grasses mentioned by Haast were palatable species such as *Poa kirkii*, *Agropyron scabrum*, *Trisetum antarcticum*, *T. youngii*, *Cockaynea laevis*, and *Hierochloe redolens*, which are now nearly confined to the mountains, where they have not yet been supplanted by the grazing-tolerant introduced species (Fig. 49).

Introduced plants are scarce in the mountains, other than mouse-ear chickweed (*Cerastium holosteoides*) and Scotch thistle (*Cirsium vulgare*), which occur fairly regularly on open places such as slips and dry river beds, and plants of the dandelion group (*Hieracium*, *Hypochoeris*, *Taraxacum*) occurring on grassy flats. Well-worn tracks through grassland are usually dotted with a leafy rush, *Juncus tenuis*, its seed apparently having been carried on the feet of men and beasts. Pockets of pasture plants have become established where supplies have been dropped from aeroplanes and on landing strips. Such introductions will probably become more important with the use of helicopters.

Burning virgin vegetation

Fire is the chief agent whereby virgin vegetation has been destroyed and replaced by successional communities, but this has happened less in Westland than in most parts of the country, because of the damp climate. The lowland forest is almost unburnable unless partly felled first, and almost none has been destroyed by uncontrolled fires. The stunted vegetation of the leached, podzolised soils of the piedmont moraines, on the other hand, becomes very inflammable during dry weather, because the woody species are mostly highly resiniferous, and the herbaceous vegetation contains a large proportion of standing dead material. Most of this peculiarly West Coast vegetation has been burnt repeatedly, and the original mosaic replaced by rather monotonous semi-swamp vegetation known as **pakihi**, consisting of tangle fern (*Gleichenia circinata*), *Baumea*, and wire-rush (*Calorophus minor*). Manuka (*Leptospermum scoparium*) persistently re-invades the better drained parts, as the first stage on the long road to recovery of the woody communities.

True swamp is also rather easily burnt in spring, because some of the common sedges die down in the winter and provide fuel in the form of dry leaves. The fires often destroy the gradual transition between swamp and tall kahikatea forest, so that the forest abruptly meets sedge-dominated vegetation.

The tall grasslands of the alpine belt are also inflammable during dry weather, but normally recover to show little trace of burning. However, on gentle slopes at tree limit, where subalpine scrub and alpine grassland interdigitate over a broad zone, the grass has carried fires which have destroyed the woody plants. A.P. Harper relates how he set fire to the vegetation on the moraines of the Horace Walker and Douglas Glaciers in January 1894 to clear the way for travellers. He predicted that the scrub would never return; and indeed, most of the burnt area is now covered by snow-tussocks, although there has been some regrowth of shrubs during the 80 years. There have been similar fires near the head of the Copland River and on the southern end of the Copla[illegible] where sheep were grazed at the end of the nineteenth century, and in neithe[illegible] scrub recovered its former extent and density.

Browsing mammals

The introduction of browsing mammals without their natural enemies brought a new factor into the ecological scene. The changes have been profound, and, while less obvious to the unobservant than the effects of fire, they affect nearly all kinds of vegetation in the national park. There are five species of mammal involved: red deer, chamois, thar, goat, and brushtail opossum. Hares and rabbits are still absent, but this will not always be so, since both are present in the lower reaches of the Landsborough Valley; hares have recently appeared on the Waiho flats, and rabbits have spread up the coast to Paringa. Harper wrote of numerous rabbits on the Landsborough flats as early as 1894; presumably they had crossed low passes from Canterbury.

Deer have spread widely through the area, although they are still very rare in the mountain country between the Whataroa and Cook Rivers. They also have the greatest range of habitats, from wet kahikatea forest and pakihi near the coast, to the limits of alpine vegetation. Their preferred habitat is grassy valley flats, but they are apt to become virtually a forest animal when persistently hunted. The kind of forest containing the greatest proportion of palatable plants, and therefore the most vulnerable to their browsing is that on talus slopes between about 500 and 1000 m (Fig. 43). The understorey of shield fern (*Polystichum vestitum*) becomes reduced to stumps and is replaced by a browse-tolerant turf of *Pratia*, *Hydrocotyle novae-zelandiae* and a related plant (*Schizeilema nitens*) with small clover-like leaves, *Nertera*, and the tiny sedge *Scirpus habrus*. Clumps of two summer-green ferns, water-fern (*Histiopteris incisa*, Fig. 6) and *Hypolepis*, develop where sunlight reaches the floor, and swards of bush rice-grass (*Microlaena avenacea*) spread over places where the soil is disturbed by rivulets during rain. The main trees, which are broadleaf (*Griselinia littoralis*), mountain ribbonwood (*Hoheria glabrata*), three-finger (*Pseudopanax colensoi*), and fuchsia (*Fuchsia excorticata*), are palatable. Their seedlings never get a chance to establish, and except for the rough-barked broadleaf, the trees themselves are apt to be killed by chewing and rubbing of bark. After some decades, the forest presents a decrepit appearance, with trees dead and collapsing, and turfy glades expanding. Eventually, there would probably be some return to forest conditions, as the unpalatable seedlings of pepperwood (*Pseudowintera colorata* — at lower altitudes) and mountain holly (*Olearia ilicifolia* — at higher altitudes) grow up to form a new canopy.

Chamois are predominantly alpine, but are also frequent in the subalpine zone and occasionally descend to low altitudes in the mountain valleys. Where they are the only animal present in large numbers, as in the upper reaches of the Callery River and at the head of the Cook River, the snow-tussock grassland remains apparently intact and the subalpine scrub is also undamaged, even the highly palatable three-finger remaining abundant. Several palatable herbs, however, have been much reduced, including Mount Cook lily (*Ranunculus lyallii*) which was so abundant in the Callery grasslands in the 1890s that travellers at a waterless camp site could fill their billies by collecting dew from the saucer-shaped leaves. The yellow flowered *Ranunculus godleyanus* was formerly common on loose talus and fans in the northern part of the park, but today it is scarce and seldom seen in flower except where inaccessible on cliffs. A carrot-like

Fig. 43 Forest mainly of mountain ribbonwood (*Hoheria glabrata*) and broadleaf (*Griselinia littoralis*) is being destroyed by deer. The trees dying from ring-barking and old age are not replaced with seedlings, and the original dense, understorey of shield fern has been replaced by low turf, scattered rushes (*Juncus gregiflorus*), and clumps of the unpalatable water fern (*Histiopteris incisa*).

plant, *Anisotome haastii*, was probably also common throughout the grassland, but it is likewise now largely confined to places less accessible to animals.

Where deer and chamois occur together, as on the Copland Range, damage to alpine and subalpine vegetation is more serious, but the worst damage is in the remote upper reaches of the Karangarua and Douglas Valleys, where deer, chamois, and thar all occur together, and where until recently there was minimal disturbance by hunters. The main culprit has been the thar; its relationship to the goat is revealed in its broad browsing spectrum, and there is little vegetation that is inaccessible to this remarkably agile animal of the high altitudes. Thar systematically destroy snow-tussock (Fig. 44) and turpentine shrub (*Dracophyllum uniflorum*), two of the most important plants of the low-alpine belt, and thereby open the country to occupation by increased numbers of chamois and deer as well. On the deeper and more developed soils, the grassland and low scrub is replaced by turfy grassland of *Poa colensoi* (the so-called blue tussock, but in this district it never has a tussock form) and mountain rice-grass (*Microlaena colensoi*). Though many of the original mountain herbs are eliminated, such as Mount Cook lily and the large speargrass which is rather unjustly named *Aciphylla horrida*, the celmisias are less affected, and one species, *Celmisia walkeri*, has greatly increased following removal of competing plants. Stony immature soils come to support turf of browse-tolerant species such as *Hydrocotyle novae-zelandiae*, the everlasting daisy *Helichrysum bellidioides* (Fig. 47), and hook-sedge, *Uncinia divaricata* (Fig. 48). On rough talus below 1200 m the fern *Hypolepis millefolium* becomes dominant over extensive areas, replacing scrub dominated by *Coprosma ciliata*, *Olearia moschata*, and shield fern.

Fig. 44 This snow tussock (*Chionochloa*) grassland has been destroyed by Himalayan thar, leaving little but dead leaf bases.

Goats have caused untold damage to vegetation in many lands, but in South Westland their effects are as yet localised. They mainly inhabit the coastal cliffs but also occur in forest near the mouth of the Cook River, extend up the valleys of the Waikukupa and Omoeroa almost to the Alpine Fault, and have entered at least one mountain valley, that of the Makawhio. Along with deer inhabiting the same areas, their main influence has been to deflect plant successions on slips, so as to favour turf and unpalatable ferns instead of young forest dominated by species such as wineberry (*Aristotelia serrata*), fuchsia, and marbleleaf (*Carpodetus serratus*).

Opossums are in a different ecological category in that although their food preferences are quite similar to those of deer, they attack foliage beyond the reach of ground-dwelling mammals. They kill or badly damage mature trees of rata (*Metrosideros umbellata*) and kamahi (*Weinmannia racemosa*), persistently thinning the crown until the trees succumb. Curiously, young trees are damaged very little, probably because they lack cavities where opossums can live. Pate (*Schefflera digitata*), three-finger, and especially fuchsia are small trees that are severely damaged or killed. Opossums

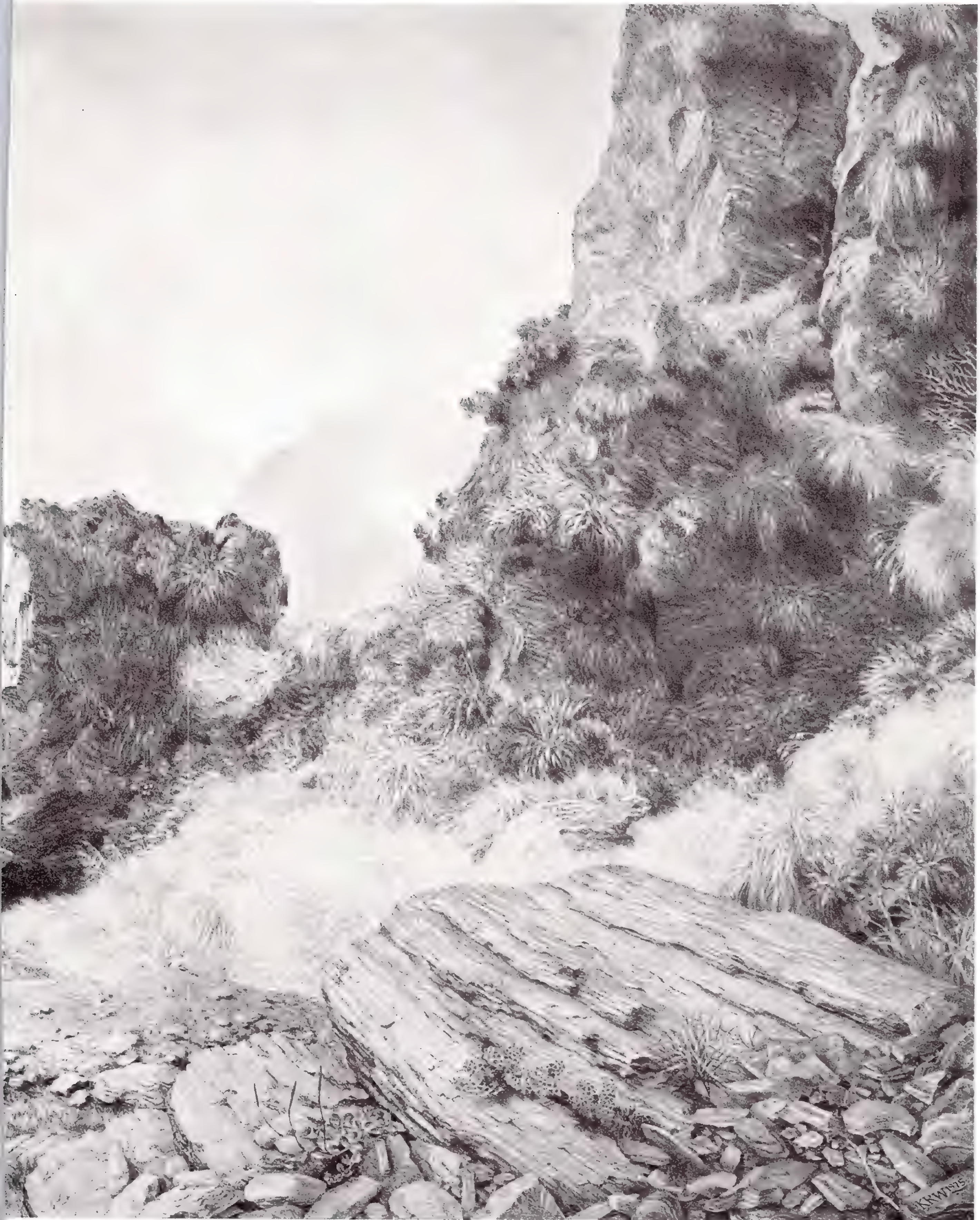
Fig. 45 On Mt. Fox, mature leatherwood (*Olearia colensoi*) shrubs have died, possibly through attacks by insects, but young plants are growing up beneath them. The other shrub is inaka (*Dracophyllum longifolium*), and there are also clumps of mountain flax (*Phormium cookianum*).

also feed on pastures beyond the forest margin, but, with the exception of crape fern (*Todea superba*) and hen-and-chicken fern (*Asplenium bulbiferum*), plants on the forest floor seem to be little touched. So far in the national park, we have not seen the virtual destruction of the forest which results when large numbers of both deer and opossums inhabit the same area.

Not all the severe damage to native vegetation can be blamed on introduced mammals (Fig. 45). Through much of the park trees of Hall's totara (*Podocarpus hallii*) are dying, even in areas such as the Copland Valley, where opossums have only arrived recently. Moribund trees of this species have most of their buds parasitised by larvae of a moth, apparently the tortricid *Ctenopseustis obliquana*, and there is some indication that a root disease may also be present. In the Waitangiroto Nature Reserve, the smaller broad-leaved trees, especially mahoe (*Melicytus ramiflorus*), lost most of their foliage and young shoots to browsing by a caterpiller in 1967; this parasite is present continuously but the unusually severe damage may have been triggered by damage from salt spray during a storm early in the summer.

Though signs of damage by opossums continue to spread in the park, the outlook in respect to the ungulates has become encouraging since 1968, when shooting and recovery of carcasses by helicoper began. Understandably, this industry distresses many people as being inhumane and unsporting, but, without doubt, the cruelties are less than those previously inflicted by amateur hunters and gross overpopulation. A botanist can only rejoice in the often-spectacular recovery of mountain vegetation. Snow-tussocks and even highly palatable species like Mount Cook lily are reappearing in grassland that had been reduced to low turf. In the subalpine scrub and upper forest, shield fern is now leafing out vigorously in places where only apparently dead stumps remained. It is too early to see how much recovery of the woody plants will occur, but we may hope that we are now witnessing a permanent reprieve for our mountain vegetation.

Fig. 46 **Habitat V.** Castle Rocks are a cluster of schist columns at 1200 m that overlook the Franz Josef Glacier. This typical low-alpine garden is dominated by snow tussocks (*Chionochloa*) and celmisias. Smaller plants visible in the right foreground are edelweiss (*Leucogenes grandiceps*) in a rock fissure and a willow-herb (*Epilobium brunnescens*) bearing seed capsules at the base of the same rock.




(i) x 7
(ii) x 7
a
(i) x 3
b
c x 1/3

Fig. 47
Low-alpine plants
a. *Euphrasia zelandica*, (i) flower x 7, (ii) leaf x 7;
b. *Helichrysum bellidioides*, (i) leaf x 3;
c. *Celmisia coriacea* x 1/3;
d. *Celmisia walkeri*;
e. *Aciphylla crenulata* x 1/3, (i) female and (ii) male inflorescences, (iii) leaf;
f. *Aciphylla horrida* leaf x 1/4.

a x 1/2

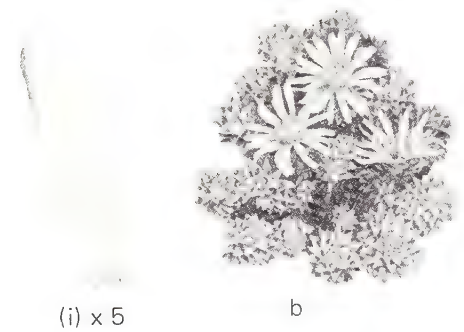
Fig. 48
Low-alpine plants ctd.
a. Mount Cook lily (*Ranunculus lyallii*) x 1/2;
b. *Uncinia divaricata*, (i) fruit x 10.

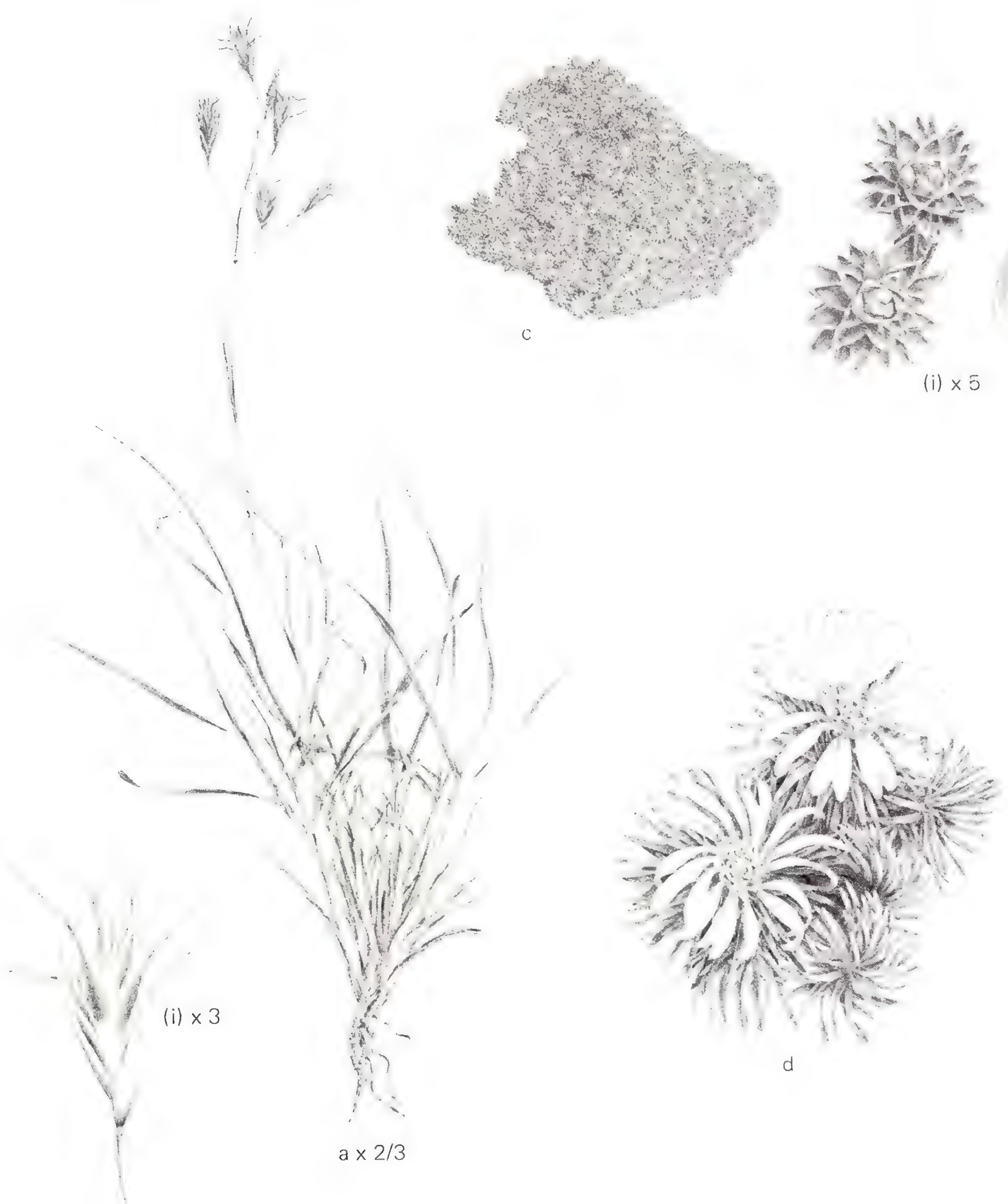
Fig. 49
Mountain grasses and a sedge
a. *Poa colensoi*, (i) spikelet x 5;
b. *Poa cockayniana* x 2/3, (i) spikelet x 5;
c. *Schoenus pauciflorus* x 1/2, (i) spikelet x 3;
d and e. inflorescences of *Cockaynea laevis* and *Trisetum antarcticum.*

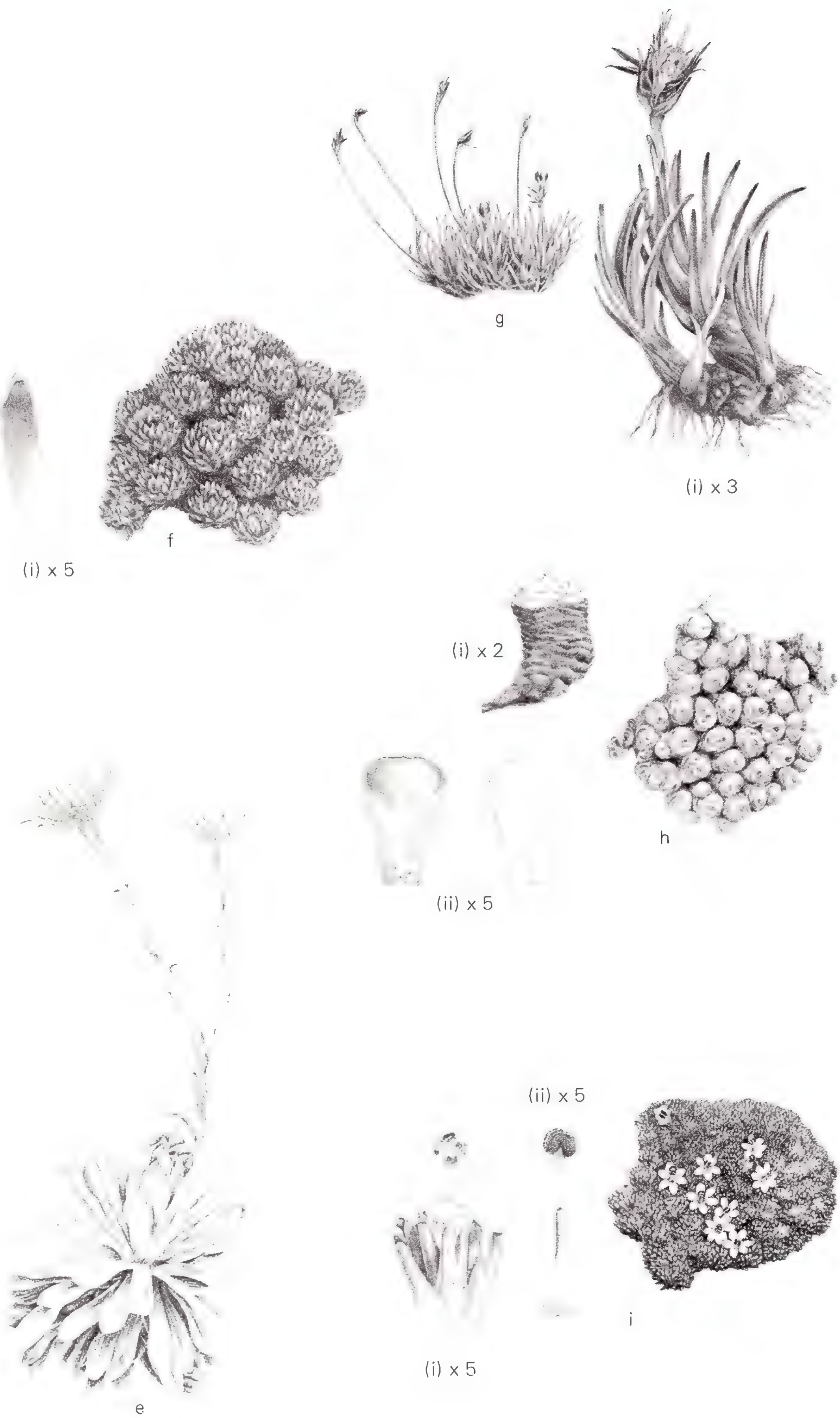

(i) x 3
c x 1/2
d
e

Fig. 50
High-alpine plants

a. *Chionochloa oreophila* x 2/3, (i) spikelet x 3;
b. *Raoulia grandiflora*, (i) leaf x 5;
c. *Drapetes lyallii*, (i) details of foliage and leaf x 5;
d. *Celmisia sessiliflora*;
e. *Celmisia hectori*;
f. *Hectorella caespitosa*, (i) leaf x 5;
g. *Luzula pumila*, (i) detail x 3;
h. *Raoulia buchananii*, (i) twig x 2, (ii) leaf both surfaces x 5;
i. *Phyllachne colensoi*, (i) leaves and flower x 5, (ii) stamen x 5.






g
(i) x 3
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i
(i) x 5
e

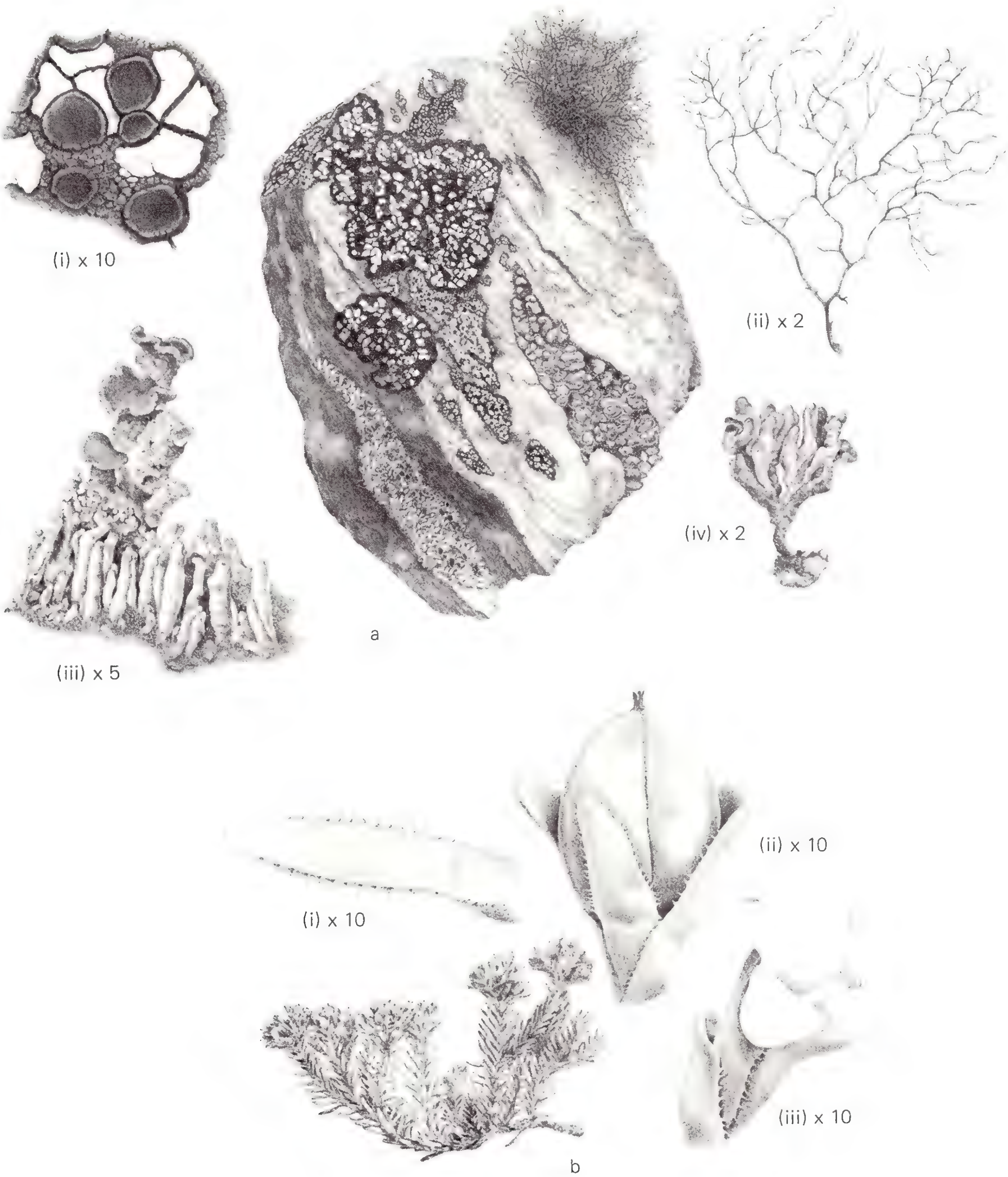

Fig. 51
High-alpine plants ctd.
a. lichens, 4 species on rock, (i) *Rhizocarpon geographicum* x 10, (ii) *Pseudephebe pubescens* x 2, (iii) *Stereocaulon caespitosum* x 5, (iv) *Toninia bullata* x 2;
b. *Hebe ciliolata*, (i-iii) leaf, capsule, and flower x 10;
c. *Parahebe birleyi* from dried specimen and photo (H.D. Wilson);
d. *Anisotome flexuosa*, (i) fruit x 10, (ii) leaf;
e. *Carex pyrenaica*;
f. *Myosotis forsteri*, (i) calyx x 5.


c
(i) x 10
e
(ii)
d
(i) x 5
f

Conclusion

The national parks of New Zealand are administered under a parliamentary Act "for the benefit and enjoyment of the public" being "areas of New Zealand that contain scenery of such distinctive quality or natural features so beautiful or unique that their preservation is in the national interest".

A few of the benefits are tangible, most are intangible. The economic value of tourism can be measured; appreciation of solitude and grand scenery, and the interest of plants, animals, and rocks to students of science are man-oriented values that are immeasurable but can be readily understood. But the greatest value cannot be expressed in terms of importance to man, for it is the intrinsic value of sanctuaries where the web of physical and biological processes can continue as in the past, unrestricted by man and his technology; where organisms can survive until they have run their evolutionary course; where the erosion natural in an evolving landscape can be healed in nature's own time by native plants.

This ideal can no longer be completely realised, even in South Westland. The extinction of several kinds of birds can never be remedied. Protection of the vegetation from introduced animals will be a continuing battle — and may it never be abandoned for reasons of economic expediency. Most of the rimu forest on the morainic hills is scheduled for eventual exploitation, and time is running out for the natural vegetation of the lowland river valleys; the swamps, the few remaining stands of matai, the developing forests of totara, kaikomako, and ribbonwood on the flood plains, and the stately but vanishing forests of kahikatea. This account of the natural history of one of the least altered parts of our country will have achieved a great deal if it helps the people of Westland and New Zealand to see that a complete sector of this wonderful landscape and vegetation should be protected in its primeval state for ever, in so far as it is still within human power to do so.

Postscript

The main text was completed during 1973 and the appendices and most of the illustrations by the end of 1977. Since 1973 I have kept the material up to date. However, two recent sequences of events have such import for the future of Westland National Park and its vegetation that they must be mentioned.

One is the continuing change in the status of introduced animals, alluded to on p. 121. Deer, chamois, and thar continue to be reduced through hunting by helicopter, to the extent that some of my remarks about damaged vegetation are now scarcely valid (although deer still concentrate in some montane forests, destroying the undergrowth and topsoil and preventing regeneration). As numbers of accessible animals decline towards the limits of economic hunting for meat, there is growing emphasis on trapping live deer for breeding stock.

Concurrently, recent legislation provides both for deer farming and for management of wild animals at levels compatible with a healthy cover of vegetation. The legal protection of native vegetation may, therefore, have been weakened, even though there is still a requirement to aim at extermination of introduced animals in national parks. No comparable legislation has been directed towards opossums, but there are nevertheless allegations of "farming" and continuing unlawful liberations.

The campaign to protect remaining lowland forest from further logging also has wide implications for native vegetation in the region. The Government's decision of April 1979 to add Waikukupa State Forest to Westland National Park adds a substantial area of terrace rimu forest. Probably, some kahikatea forest will also be included, which will partly compensate for recent destruction by floods of most of the kahikatea forest already in the park; but the major reserves of this species will have to be sought elsewhere. Nevertheless, Westland National Park has now been assigned the responsibility of protecting, forever, a large segment of the Westland landscape from the Alps to the sea.

Appendix 1

Lists of species characteristic of the main classes of vegetation

The distribution of listed species is indicated as follows:

a Especially abundant plants (usually those dominant in their storey).

r Species that are uncommon, or which grow in only a few localities. Such plants are listed only when they possess some special botanical interest.

C Plants found mainly near the coast.

* Plants that become common in vegetation damaged by browsing mammals.

Other categories are explained with each table.

Table A1. Tall forest on slopes below 400 m.

P = only on ridge crests with soils entering podzol stage.

TALL TREES

Dacrydium cupressinum	Rimu	abundant
Elaeocarpus dentatus	Hinau	uncomm. rP ridge
E. hookerianus	Pokaka	
Metrosideros umbellata	Rata, S.	
Podocarpus ferrugineus	Miro	a
P. hallii		a
Quintinia acutifolia		a
Weinmannia racemosa	Kamahi	a
Prumnopitys ferruginea		

SMALL TREES

Ascarina lucida		
Griselinia littoralis	Papauma Kapuka	
Hedycarya arborea	Porokaiwhiri	a
Myrsine australis	Mapou, Matipo	a
M. salicina	Toro	rP
Phyllocladus alpinus	Mt. Toatoa	P
Pseudopanax colensoi	Orihou	
P. edgerleyi	Raukawa	r
P. simplex	Haumakaroa	a
Pseudowintera colorata	Horopito	a
Schefflera digitata	Pate, Patete	a

SHRUBS

Alseuosmia pusilla		r
Coprosma foetidissima		
C. lucida	Karamu	a
C. rhamnoides		a
C. ciliata		
Myrsine divaricata		
Neomyrtus pedunculata	Rohutu	a

TREE FERNS

Cyathea smithii	Katote	a
Dicksonia squarrosa	Wheki	a

LIANES

Freycinetia banksii	Kiekie	a
Metrosideros diffusa	White rata	a
M. fulgens	Winter fl. rata	a
M. perforata	White rata	
Phymatodes diversifolium	Kowaowao →	a Phymatosorus diversifolius
Ripogonum scandens	Supplejack Kareao	a
Rubus cissoides	Bush lawyer	

EPIPHYTES

Asplenium (falcatum) polyodon Petake	
A. flaccidum Makawe o Raukatauri Hang	
Astelia solandri Kowharawhara	
Dendrobium cunninghamii Winika	
Earina autumnalis	
E. mucronata	
Griselinia lucida Puka	
Hymenophyllum *spp*	a
Luzuriaga parviflora Nohi	
Lycopodium varium	
(billardieri novae-zelandicum)	

GROUND FERNS AND CLUBMOSSES

Asplenium bulbiferum Mouki	
Blechnum capense	a
B. discolor Piupiu, Crown fern	a
Dicksonia lanata Tuokura	rP
Gleichenia circinata Tangle Fern	P
Hymenophyllum bivalve	rP

Crape fern, Prince of Wales Feathers

Lycopodium volubile Waewaekoukou	P
(Todea) superba Leptopteris Heruheru, Ngutungutu kiwi	
Trichomanes reniforme Raurenga, Kidney F.	a
T. strictum	r

GRASSES AND SEDGES

Gahnia procera Takahikahi	P
G. xanthocarpa	aC
Microlaena avenacea Bush rice grass	f

OTHER GROUND HERBS

Astelia fragrans Bush lily,	
A. nervosa Kakaha, Bush Flax	aP
Dianella nigra Turutu	P
Libertia pulchella	P
Nertera depressa	a
N. *cf.* dichondraefolia	a

Table A2. Tall forest on slopes above 600 m.

I = only on immature soils (e.g. talus slopes).

TALL TREES

Libocedrus bidwillii	a
Metrosideros umbellata	a
Podocarpus hallii	a
Weinmannia racemosa	a

SMALL TREES

Dracophyllum traversii	
Griselinia littoralis	a
Hoheria glabrata	I
Olearia ilicifolia	I
O. lacunosa	I
Pseudopanax colensoi	
P. simplex	a
Pseudowintera colorata	a

SHRUBS

Archeria traversii	
Coprosma astonii	
C. foetidissima	a
C. pseudocuneata	a
C. ciliata	
Myrsine divaricata	
Pseudopanax linearis	
Senecio bennettii	

LIANES

Phymatodes diversifolium	
Rubus cissoides	

EPIPHYTES

Asplenium flaccidum	
Hymenophyllum *spp.*	
Luzuriaga parviflora	

GROUND FERNS

Blechnum capense	a
B. fluviatile	a
Cyathea colensoi	a
Histiopteris incisa	*
Hypolepis millefolium	I
H. rufobarbata	
Polystichum vestitum	a
Todea superba	

GRASSES AND SEDGES

Gahnia procera	
Microlaena avenacea	a*
Uncinia *spp.*	a

OTHER GROUND HERBS

Astelia nervosa	a
Nertera *cf.* dichondraefolia	
Phormium cookianum	

Table A3. Subalpine low forest and scrub.

I = mainly on immature soils of steep gullies and talus slopes.
S = mainly in successional scrub on moraines, stream banks, etc.
L = in low scrub or in openings.

SMALL TREES AND LARGE SHRUBS

Dacrydium biforme	r
Dracophyllum longifolium	a
Griselinia littoralis	
Hoheria glabrata	al
Olearia colensoi	a
O. ilicifolia	al
O. lacunosa	a
Phyllocladus alpinus	r
Pseudopanax colensoi	a
Senecio bennettii	

OTHER SHRUBS

Aristotelia fruticosa	S
Coprosma astonii	
C. depressa	al
C. pseudocuneata	a
C. rugosa	S
C. serrulata	
C. ciliata	
Dracophyllum fiordense	L
D. uniflorum	L
Hebe subalpina	S
Myrsine divaricata	
M. nummularia	SL
Olearia nummularifolia	S
Pittosporum crassicaule	
Podocarpus nivalis	L
Pseudopanax linearis	

FERNS

Blechnum capense	a
Hymenophyllum multifidum	a
Hypolepis millefolium	al
Polystichum vestitum	al

GRASSES AND SEDGES

Chionochloa conspicua	
C. *cf.* flavescens	L
Uncinia angustifolia	

OTHER HERBS

Anisotome haastii	L
Astelia nervosa	a
Epilobium chlorifolium	S
Forstera sedifolia	L
Gentiana *cf.* patula	L
Hydrocotyle novae-zelandiae	I*
Phormium cookianum	a
Pratia angulata	*
Ranunculus hirtus	I*

TABLE A4. The denser low-alpine communities (excluding bogs and tarns).

L = mainly in low scrub.
G = mainly in dense snow-tussock grassland.
R = mainly in less dense grassland, e.g., on very rocky ground, exposed ridges, and areas damaged by animals.
W = mainly in poorly drained grassland.
T = mainly on steep talus slopes.

SHRUBS

Aristotelia fruticosa	T
Coprosma cheesemanii	aGT
C. ciliata	aT
C. depressa	GT
C. serrulata	L
Dracophyllum kirkii	R
D. menziesii	rG
D. uniflorum	aL
Gaultheria rupestris	L
Hebe macrantha	L
H. treadwellii	rR
Hymenanthera alpina	rR
Pseudopanax colensoi	L

VERY SMALL SHRUBS WITH CREEPING, ROOTING STEMS OR RHIZOMES

Coprosma pumila	R
Cyathodes pumila	R
Gaultheria depressa	aRW
Muehlenbeckia axillaris	GR
Myrsine nummularia	R
Pentachondra pumila	rR
Pimelea oreophila	rR

FERNS AND CLUBMOSSES

Blechnum penna-marina	LT
Hymenophyllum multifidum	LR

Hypolepis millefolium	aT
Lycopodium fastigiatum	aL
Polystichum vestitum	LT

GRASSES, SEDGES, AND RUSHES

Agrostis dyeri	G
Carex libera	rW
Chionochloa crassiuscula	aW
C. *cf.* flavescens	T
C. pallens	aG
C. *cf.* rigida	LW
Hierochloe recurvata	LG
Luzula *spp.*	R
Microlaena colensoi	AGR
Notodanthonia setifolia	aR
Oreobolus impar	W
Poa cockayniana	aT
Poa colensoi	aGRW
Schoenus pauciflorus	aRW
Uncinia divaricata	aLR

ERECT, TUFTED HERBS

Aciphylla crenulata	aG
A. horrida	G
Anisotome haastii	aL
Astelia nervosa	G
A. nivicola	rG
A. petriei	G
Bulbinella gibbsii	rG
Celmisia armstrongii	G
C. coriacea	GT
C. gracilenta	R
C. petiolata	G
C. vespertina	L
Craspedia *spp.*	GW
Gentiana *cf.* patula	L
Ourisia macrocarpa	R
Phormium cookianum	LG
Prasophyllum colensoi	rR
Ranunculus lyallii	aLGT
Senecio scorzoneroides	GR

SPRAWLING, CREEPING, RHIZOMATOUS, OR MAT-FORMING HERBS, OR LOW ROSETTES

Acaena anserinifolia	T
Anisotome aromatica	aG
Astelia linearis	aW
Caltha novae-zelandiae	aW
Cardamine debilis	G
Celmisia du-rietzii	R
C. glandulosa	aW
C. sessiliflora	R
C. walkeri	aR
Cotula squalida	G*
Epilobium alsinoides	R
E. chlorifolium	T
Euphrasia zelandica	aR
Forstera *spp.*	R
Gentiana bellidifolia	R
Geum parviflorum	R
Helichrysum bellidioides	aR
Hydrocotyle novae-zelandiae	aRT
Plantago *spp.*	R
Pratia angulata	GT
Raoulia grandiflora	R
Taraxacum magellanicum	T
Viola cunninghamii	aGT
Wahlenbergia pygmaea	aR

Table A5. High-alpine plants

G = grassy and herbaceous swards.
M = open mat and cushion communities on exposed sites.
T = sparsely vegetated talus slopes.
S = hollows where snow lasts late into summer.
R = rock crevices.

SMALL SHRUBS

Hebe ciliolata	R
H. treadwellii	R

FERNS AND CLUBMOSSES

Lycopodium australianum	M
L. fastigiatum	G
Polystichum cystostegia	T

GRASSES, SEDGES, AND RUSHES

Agrostis magellanica	M
Carex pyrenaica	aS
Chionochloa oreophila	aG
C. pallens	G
Luzula *spp.*	aM
Marsippospermum gracile	aG
Microlaena colensoi	G
Notodanthonia setifolia	R
Poa colensoi	aG
P. novae-zelandiae	aTR

TUFTED, MORE-OR-LESS ERECT HERBS

Aciphylla *cf.* multisecta	G
Anisotome pilifera	T
Celmisia vespertina	G
Gentiana divisa	M
Myosotis *spp.*	TR

Parahebe birleyi	rR
Ranunculus buchananii	rR
R. godleyanus	rT
R. sericophyllus	aTS
Schizeilema haastii	aT
Senecio scorzoneroides	T

PLANTS FORMING DENSE MATS OR CUSHIONS

Anistome imbricata	aGM
Celmisia hectori	rM
C. sessiliflora	GM
Colobanthus canaliculatus	S
C. monticola	aM
Coprosma pumila	G
Drapetes lyallii	aGM
Hectorella caespitosa	aM
Pernettya alpina	GM
Phyllachne colensoi	GM
Pygmea ciliolata	aMR
Raoulia grandiflora	aGM
R. subulata	aS

HERBS FORMING OPEN MATS OR OF DIFFUSE GROWTH

Anisotome flexuosa	aGM
Celmisia du-rietzii	G
C. haastii	G
Claytonia australasica	T
Cotula pectinata	M
Epilobium ***spp.***	aT
Euphrasia ***spp.***	GR
Forstera ***cf.*** sedifolia	G
Gentiana bellidifolia	G
Leucogenes grandiceps	R
Ourisia caespitosa	R
O. sessilifolia	SR
Pratia macrodon	T

Table A6. The first 1000 years of the plant succession on gravel and moraine deposited during retreat of the Franz Josef and Fox Glaciers.

The capital letters indicate the stage at which mature plants of each species are most likely to be found.

P = pioneer stage.
H = herbaceous vegetation and scattered shrubs.
S = dense scrub.
Y = early forest stages.
F = tall, complex forest.

TALL TREES

Dacrydium cupressinum	F
Metrosideros umbellata	aY
Podocarpus ferrugineus	F
P. hallii	F
Weinmannia racemosa	aYF

SMALL TREES

Aristotelia serrata	SY
Carpodetus serratus	Y
Fuchsia excorticata	aY
Griselinia littoralis	aY
Hedycarya arborea	YF
Melicytus ramiflorus	YF
Myrsine australis	Y
Olearia ilicifolia	S
O. lineata	rS
Pennantia corymbosa	Y
Pittosporum colensoi	Y
Pseudopanax colensoi	Y
P. crassifolius	Y
P. simplex	Y
Pseudowintera colorata	Y
Schefflera digitata	aYF

SHRUBS

Aristotelia fruticosa	S
Carmichaelia ***cf.*** grandiflora	aHS
Coprosma foetidissima	Y
C. lucida	Y
C. parviflora	S
C. rugosa	'aHS
C. ciliata	Y
Coriaria arborea	aHS
Dracophyllum longifolium	S
Hebe salicifolia	HS
H. subalpina	rH
Myrsine divaricata	SY
Olearia arborescens	HS
O. avicenniaefolia	aHS
O. colensoi	rS
Senecio bennettii	rS

TREE FERNS

Cyathea smithii	aYF
Dicksonia squarrosa	YF

LIANES

Metrosideros diffusa	F
Phymatodes diversifolium	aYF
Ripogonum scandens	F
Rubus cissoides	F

EPIPHYTES

Asplenium flaccidum	Y
Hymenophyllum ***spp.***	YF
Lycopodium varium	YF

DWARF AND CREEPING SHRUBS AND SEMI-WOODY PLANTS

Carmichaelia nigrans	H
Coprosma brunnea	H
Coriaria plumosa	H
Parahebe linifolia	rH
P. lyallii	H
Pernettya macrostigma	rH

GROUND FERNS

Asplenium bulbiferum	aYF
Blechnum capense	aHSY
B. fluviatile	H
B. penna-marina	S
Phymatodes diversifolium	aS
Polystichum vestitum	SY

GRASSES, SEDGES, AND RUSHES

Chionochloa conspicua	H
C. ***cf.*** flavescens	rH
Cortaderia richardii	H
Festuca matthewsii	H
Lachnagrostis lyallii	PH
Luzula ***spp.***	H
Notodanthonia gracilis	H
N. setifolia	H
Poa cockayniana	PH
P. novae-zelandiae	PH
Uncinia divaricata	P
U. uncinata	Y

ERECT, TUFTED HERBS

Angelica montana	H
Astelia fragrans	SY
A. nervosa	SY
Celmisia coriacea	rH
Epilobium glabellum	aPH
Microtis unifolia	PH
Phormium cookianum	rS

WEAK, CREEPING, OR RHIZOMATOUS HERBS

Acaena anserinifolia	S
Cardamine debilis	S
Epilobium brunnescens	aPH
Galium perpusillum	S
Geum parviflorum	rH
Gnaphalium trinerve	H
Gunnera dentata	PH
G. monoica	PH
Haloragis depressa	H
Hypochoeris radicata	PH
Lagenifera petiolata	HS
Mentha cunninghamii	rH
Nertera ciliata	PH
N. depressa	aYF
N. ***cf.*** dichondraefolia	aY
Pratia angulata	P
Pterostylis ***spp.***	SY
Raoulia hookeri	aP
R. tenuicaulis	aPH

Table A7. The stages of declining fertility on piedmont moraines.

F = tall forest.
S = low forest or dense scrub.
H = low, open scrub or herbaceous vegetation.
+ = very stunted when on poor soils.

TALL TREES

Dacrydium cupressinum	aF
Elaeocarpus hookerianus	FS+
Libocedrus bidwillii	rS
Metrosideros umbellata	FS+
Podocarpus ferrugineus	aF
P. hallii	FS+
Quintinia acutifolia	aF
Weinmannia racemosa	aFS+

SMALL TREES

Ascarina lucida	F
Dacrydium biforme	aS+
D. colensoi	aFS+
D. intermedium	S
Griselinia littoralis	F
Myrsine australis	F
Phyllocladus alpinus	aFS+
Pseudopanax colensoi	FS
P. crassifolius	F

P. simplex	FS
Pseudowintera colorata	F

SHRUBS

Cassinia vauvilliersii	rH
Coprosma colensoi	FS
C. foetidissima	FS
C. lucida	F
C. parviflora	F
C. rhamnoides	F
Cyathodes juniperina	S
Dacrydium bidwillii	H
Dracophyllum longifolium	S+
D. palustre	HS
Leptospermum scoparium	aSH+
Myrsine divaricata	F
Neomyrtus pedunculata	aFS
Pittosporum crassicaule	rS
Podocarpus acutifolius	rS

TREE FERNS

Dicksonia squarrosa	F

LIANES

Freycinetia banksii	FC
Metrosideros *spp.*	aF

EPIPHYTES

Asplenium falcatum	F
A. flaccidum	F
Astelia solandri	F
Dendrobium cunninghamii	F
Hymenophyllum *spp.*	F

DWARF AND CREEPING SHRUBS

Cyathodes empetrifolia	H
Dacrydium laxifolium	H
Pentachondra pumila	H

GROUND FERNS AND CLUBMOSSES

Blechnum capense	aFS
Gleichenia circinata	aSH
G. cunninghamii	F
Hymenophyllum multifidum	S
Hypolepis rufobarbata	F
Lycopodium ramulosum	aH
L. volubile	F
Todea superba	F
Trichomanes reniforme	aF

GRASSES, SEDGES, AND RUSHES

Baumea *spp.*	H
Calorophus minor	aSH
Carpha alpina	H
Centrolepis ciliata	H
Chionochloa rubra	H
Gahnia procera	SH
G. rigida	H
G. xanthocarpa	FC
Lepidosperma australe	aH
Microlaena avenacea	F
Oreobolus *spp.*	rH
Uncinia *spp.*	FS

OTHER HERBS

Anisotome aromatica	rH
Aporostylis bifolia	rS
Astelia linearis	rS
A. nervosa	FS
Celmisia graminifolia	aH
Dianella nigra	F
Donatia novae-zelandiae	rH
Drosera stenopetala	S
D. *spp.*	aH
Gentiana *cf.* spenceri	H
Libertia pulchella	FS
Luzuriaga parviflora	FS
Nertera depressa	aF
N. *cf.* dichondraefolia	aF
Senecio bellidioides	rH
Thelymitra venosa	H

Table A8. Low forest of steep gullies and unstable talus.

L = at low and mid altitudes.
H = mainly subalpine.

TALL TREES

Weinmannia racemosa	L

SMALL TREES

Carpodetus serratus	L
Fuchsia excorticata	L
Griselinia littoralis	
Hedycarya arborea	aL
Hoheria glabrata	aH
Melicytus ramiflorus	aL
Myrsine australis	L
Olearia colensoi	H
O. ilicifolia	H
Pseudopanax colensoi	H
Schefflera digitata	aL

SHRUBS	
Coprosma depressa	aH
C. foetidissima	L
C. lucida	L
C. ciliata	H
Myrsine divaricata	H
Senecio bennettii	H

TREE FERNS	
Cyathea cunninghamii	rL
C. medullaris	rL
C. smithii	aL
Dicksonia squarrosa	L

LIANES	
Freycinetia banksii	L
Metrosideros diffusa	L
M. fulgens	L
Muehlenbeckia australis	L
Phymatodes diversifolium	L
Ripogonum scandens	aL
Rubus cissoides	L

EPIPHYTES	
Asplenium falcatum	L
A. flaccidum	L
Astelia solandri	L
Hymenophyllum *spp.*	L
Trichomanes venosum	L

GROUND FERNS	
Asplenium bulbiferum	aL
Blechnum fluviatile	
B. lanceolatum	
Hypolepis millefolium	aH*
Polystichum vestitum	aH
Todea hymenophylloides	L

GRASSES AND SEDGES	
Chionochloa conspicua	H
Poa breviglumis	H*
Uncinia *spp.*	

OTHER GROUND HERBS	
Astelia nervosa	H
Cardamine debilis	H
Hydrocotyle novae-zelandiae	H*
Nertera *spp.*	L
Phormium cookianum	H
Ranunculus hirtus	H

Table A9. The commoner species of lowland grassy flats.

P = mainly in pioneer stages.
W = mainly in damp hollows.
+ = introduced species.
x = native and introduced species in genus.

TREES AND SHRUBS	
Coprosma propinqua	a
Podocarpus totara	a
Ulex europaeus	+
(Further species grow in forest margins.)	

DWARF SHRUBS, MAINLY CREEPING OR RHIZOMATOUS	
Coprosma brunnea	
Cyathodes fraseri	
Muehlenbeckia axillaris	
Pernettya macrostigma	
Pimelea prostrata	
Rubus parvus	

FERNS	
Blechnum penna-marina	

GRASSES, SEDGES, AND RUSHES	
Agrostis tenuis	+
Anthoxanthum odoratum	a+
Carex coriacea	W
C. testacea	a
Cortaderia richardii	
Eleocharis acuta	W
Festuca arundinacea	W+
F. matthewsii	
F. rubra	+
Glyceria fluitans	W+
Holcus lanatus	a+
Juncus *spp.*	aWx
Lachnagrostis lyallii	P
Lolium perenne	+
Luzula *spp.*	x
Notodanthonia *spp.*	
Poa laevis	a
Schoenus nitens	W
Uncinia egmontiana	a
Vulpia myuros	P+

HERBS GROWING MAINLY AS SINGLE ROSETTES OR TUFTS	
Cerastium holosteoides	+
Epilobium *spp.*	P
Hypochoeris radicata	a+
Lotus pedunculatus	a+
Microtis unifolia	
Myosotis caespitosa	W+
Senecio jacobaea	+
Sisyrinchium "chilense"	+
Stellaria graminea	W+
Taraxacum officinale	+
Veronica serpyllifolia	+

HERBS WITH RHIZOMES OR CREEPING, ROOTING STEMS	
Centella uniflora	
Cirsium arvense	P+
Cotula squalida	a
Epilobium brunnescens	aP
Galium palustre	W+
G. perpusillum	a
Gunnera dentata	P
G. monoica	P
G. prorepens	r
Haloragis depressa	
Helichrysum filicaule	
Hydrocotyle novae-zelandiae	a
H. tripartita	W
Lagenifera petiolata	a
Mazus radicans	
Nertera setulosa	
Potentilla anserinoides	W
Pratia angulata	a
Ranunculus lappaceus	
R. repens	W+
Raoulia hookeri	P
R. tenuicaulis	aP
Schizeilema nitens	W
Trifolium dubium	+
Viola *spp.*	

Table A10. Lowland forest on alluvial flats formed in the last 1000 years.

E = mainly in early forest stages or at margins.

TALL TREES	
Dacrydium cupressinum	
Elaeocarpus hookerianus	
Metrosideros umbellata	
Plagianthus betulinus	
Podocarpus dacrydioides	a
P. ferrugineus	
P. hallii	
P. spicatus	
P. totara	aE
Weinmannia racemosa	a

SMALL TREES	
Aristotelia serrata	E
Ascarina lucida	
Carpodetus serratus	
Cordyline australis	rE
Fuchsia excorticata	
Griselinia littoralis	
Hedycarya arborea	
Melicytus ramiflorus	a
Myrsine australis	
Pennantia corymbosa	aE
Pseudopanax colensoi	
P. crassifolius	
Pseudowintera colorata	
Schefflera digitata	
Sophora microphylla	CE

SHRUBS	
Coprosma foetidissima	
C. lucida	
C. propinqua	E
C. rhamnoides	
C. rotundifolia	a
C. ciliata	a
Fuchsia perscandens	rE
Myrsine divaricata	
Neomyrtus pedunculata	
Pittosporum colensoi	E
Pseudopanax anomalus	E

TREE FERNS	
Cyathea smithii	a
Dicksonia fibrosa	r
D. squarrosa	a

LIANES	
Clematis paniculata	E
Freycinetia banksii	aC
Metrosideros *spp.*	a
Muehlenbeckia australis	E
Parsonsia heterophylla	
Phymatodes diversifolium	
Ripogonum scandens	a
Rubus australis	
R. schmidelioides	E

EPIPHYTES	
Asplenium falcatum	
A. flaccidum	
Astelia solandri	
Bulbophyllum pygmaeum	

Dendrobium cunninghamii	
Earina autumnalis	
E. mucronata	
Griselinia lucida	
Hymenophyllum ***spp.***	a
Lycopodium varium	
Pyrrosia serpens	
Trichomanes venosum	

GROUND FERNS AND CLUBMOSSES

Asplenium bulbiferum	a
Blechnum capense	
B. fluviatile	
B. lanceolatum	
Histiopteris incisa	
Hypolepis rufobarbata	r
Polystichum vestitum	E

Todea superba	
Trichomanes reniforme	

GRASSES, SEDGES, AND RUSHES

Gahnia xanthocarpa	aC
Juncus gregiflorus	rE
Microlaena avenacea	a
Uncinia ***spp.***	a

OTHER HERBS

Astelia grandis	
Cardamine debilis	
Nertera ***spp.***	a
Pterostylis ***spp.***	

Table A11. Lowland swamps.

F = mainly in fertile swamps.
I = mainly in infertile swamps.
V = extremely infertile sites (this overlaps with category H in Table A7).

TREES

Cordyline australis	F

SHRUBS

Carmichaelia arborea	F
Coprosma ***cf.*** brunnea	I
C. parviflora	IF
C. propinqua	aF
Dacrydium bidwillii	rV
D. colensoi	I
Dracophyllum palustre	I
Hebe salicifolia	aF
Leptospermum scoparium	aI
Myrsine divaricata	F
Olearia virgata	I

FERNS AND CLUBMOSSES

Blechnum capense	aFI
Gleichenia circinata	aI
Lycopodium ramulosum	aV

GRASSES, SEDGES, AND RUSHES

Baumea ***spp.***	aI
Calorophus minor	aI
Carex coriacea	aF
C. dissita	F
C. echinata	I
C. gaudichaudiana	aFI
C. secta	aF
C. virgata	aF
Centrolepis ciliata	aI
Chionochloa rubra	V
Eleocharis acuta	aF
Gahnia rigida	aI
Juncus ***spp.***	aF
Leptocarpus similis	I
Lepidosperma australe	I
Oreobolus ***spp.***	V
Typha orientalis	rFI

OTHER HERBS

Astelia grandis	F
Bulbinella modesta	I
Celmisia graminifolia	I
Donatia novae-zelandiae	rV
Drosera ***spp.***	IV
Epilobium ***spp.***	F
Euphrasia disperma	rV
Galium palustre	F
Haloragis micrantha	V
Hydrocotyle novae-zelandiae	aF
Lotus pedunculatus	F
Phormium tenax	aF
Ranunculus flammula	F
Thelymitra venosa	V
Utricularia novae-zelandiae	V
Viola lyallii	F

Appendix 2

Descriptive index of plants

This appendix lists all plants mentioned in the main text. Most entries are annotated with sufficient information to make at least a tentative identification when used in combination with the text and illustrations. More than 60 percent of the total vascular flora of some 740 native and introduced plants are mentioned, the remainder consisting of rare, inconspicuous, or difficult species that can be identified only by reference to a standard flora. It should also be noted that characteristics described are intended only to distinguish among species growing in the park and its immediate neighbourhood. Species names generally are those provided by the most recent floras (see reference list). Although many of these names are already out of date, they are used because non-botanists do not have ready access to the scattered technical papers where revisions are published. However, equivalent up-to-date names are listed at the end of the appendix. As yet, there is no recent flora covering the grasses, and some of the names will be found only in technical papers.

Common names are also entered alphabetically and related to the appropriate Latin names.

Acaena (p. 109). Creeping herbs with round seed-heads equipped with clinging barbs. Fig. 28 illustrates *A. anserinifolia*, which is widespread in grassland and shrubland.

Aciphylla. Tufted umbellifers with leaflets narrowing into sharp spines. The species in the park are the metre-tall *A. horrida* (pp. 13, 54, 121; Fig. 47), *A. crenulata* (p. 13; Fig. 47) and the small high-alpine *A.* cf. *multisecta*.

Actinomycetes (p. 47). A group of yeast-like soil fungi.

Agathis australis (pp. 47, 112). The largest New Zealand conifer, native to Auckland province.

Agropyron scabrum (p. 109, 117). A grass with bluish stems and leaves, spikelets arranged in two rows as in the related *Cockaynea laevis* (q.v.), but awns long and curving.

Agrostis tenuis (p. 117). A rhizomatous introduced grass with open panicles of tiny brown spikelets. The genus also includes *A. stolonifera*, which grows mainly near the coastal lagoons, and three native species, one of which (*A. magellanica*) is a tufted grass common in the high-alpine belt. *Lachnagrostis lyallii*, a turfy grass of stony flats, has panicles very similar to those of *Agrostis*, excepting that the central stalk zigzags. The whole panicle snaps off when ripe, to blow around as a tumbleweed.

Akeake. See *Olearia avicenniaefolia.*

Algae (pp. 17, 47, 74, 75). Photosynthetic plants of simple structure, not organised into stems, leaves, roots, etc. See also *Trentepohlia.*

Alseuosmia pusilla (p. 108). A sparsely branched shrub of lowland forest, superficially resembling *Pseudowintera colorata* but differing in the pale green undersurface of the leaves, tubular flowers, and larger berries.

Ammophila arenaria (p. 87). A robust, rhizomatous grass, abundant on many sand dunes.

Angelica montana. See under *Anisotome.*

Anisotome. A genus of aromatic umbellifers. The high-alpine *A. flexuosa* (p. 18) is illustrated (Fig. 51). *A. aromatica*, which is abundant in subalpine and low-alpine grassland, has a more open flower-head and longer leaf-stalks whereas *A. imbricata* (p. 18) forms tight cushions. Two much larger plants are *A. haastii* (pp. 13, 121), which has finely divided leaves up to 30 cm tall, and the rather parsnip-like, glaucous *A.*

pilifera which grows on alpine talus. *Angelica montana* is similar to *A. pilifera*, but lacks the bristles typical of *Anisotome* leaves. A plant with a strong taste and smell of aniseed, it is common (in the absence of grazing) on montane grassy river flats and on rock ledges.

Anthoxanthum odoratum. An abundant, introduced, tufted grass with spikelets in dense, cylindrical heads 3-5 cm long.

Aponogeton distachyus (p. 75). A water weed with oval, floating leaves and spikes of white flowers held above the water.

Aporostylis bifolia. An orchid with white flowers and two spotted leaves, common in subalpine grassland and scrub.

Araucarians (p. 96). Conifers of ancient lineage, represented today by kauri, Norfolk pine, monkey puzzle tree, and a few other species.

Archeria traversii. A large, spreading shrub found mainly on ridge crests in high-altitude forests and subalpine scrub. The small, hard, close-set leaves are like those of *Leptospermum scoparium*, but the small, bell-like flowers show it to be a heath.

Aristotelia serrata (pp. 20, 122; Fig. 21). An abundant small tree colonising open lowland and montane sites, with small, rose-coloured flowers. *A. fruticosa* (p. 18; Fig. 12) is a divaricating shrub found on recent soils in the montane and subalpine belts. It forms natural hybrids with *A. serrata* despite its dissimilar appearance.

Ascarina lucida (p. 14; Fig. 3). The leaves are glossy and yellowish green.

Asplenium. Ferns characterised by elongated pouches on the backs of the fronds, which protect the spores. *A. bulbiferum* (pp. 49, 54, 123; Fig. 22) is a tall, tufted species of lowland and montane forest on young soils; the plantlets borne on the frond margins distinguish it from other ferns. *A. obtusatum* creeps over coastal rocks and tree bases. The frond illustrated in Fig. 34 is from an exposed forest margin; more sheltered plants have longer pointed leaflets. The tufted, pendant, lowland epiphyte, *A. falcatum* (p. 16; Fig. 8), also has undivided leaflets, and these readily distinguish it from *A. flaccidum* (p. 16; Fig. 10) which ascends to higher altitudes.

Astelia. Plants of the lily family with generally densely tufted, longitudinally pleated leaves and panicles bearing small, greenish flowers and fleshy fruit. The epiphytic *A. solandri* (p. 12; Fig. 9) is illustrated. *A. nervosa* (p. 12) is the most widespread and extends from lowland forest on poor soils through upland forest and scrub into low-alpine grassland. Its leaves are 0.5–1.5 m long and usually have a silvery or bronze sheen imparted by a layer of scales. *A. fragrans* (p. 49) grows in forest on young lowland soils and forms larger tussocks with bright green leaves that tend to droop at the tips. *A. grandis* (p. 70), on the other hand, grows on wet soils and the margins of swamps and has robust, stiffly erect, pale green leaves.

Three species are almost confined to low-alpine grassland: *A. petriei* with yellowish, curved, broadly tapering leaves; *A. nivicola* with narrow , silvery-bronze leaves less than 1 cm across; and the patch-forming *A. linearis* (p. 53) with leaves only 2-3 cm long. There is also a variety of *A. linearis* in wet piedmont scrub.

Athrotaxis (p. 97). Southern hemisphere relatives of sequoias and swamp cypresses.

Azolla (p. 74). A floating fern that forms a red layer on the surface of ponds.

Bacteria (p. 47). Single-celled plants lacking nuclei or true chlorophyll.

Batchelor's buttons. *Cotula*

Baumea (pp. 50, 118). Sedges of infertile swamp, pakihi, and heathland with rush-like leaves and stems, the latter bearing open or fairly dense terminal panicles of small spikelets. *B. teretifolia* (Fig. 25) is the main species on frequently burnt pakihi, although here and elsewhere it is usually accompanied by *B. tenax* which is far more slender, has light green rather than dark green stems, and has a panicle in which the spikelets are well-spaced instead of aggregated. *B. rubiginosa* (p. 71) is taller and usually grows in pools and shallow swamps.

Beech. See *Nothofagus*

Beech, silver. *Nothofagus menziesii*

Bidibid. *Acaena*

Blackberry. *Rubus fruticosus*

Bladderwort. *Utricularia*

Blechnum. Ferns with pinnate fronds which differ according to whether or not they carry spores. In sporing fronds the leaflets are thong-like, whereas in sterile fronds they are broad and green. *B. discolor* (p. 11), the abundant crown-fern of lowland and montane forests, is shown in Fig. 6. Fronds of the mountain form of the equally abundant, rhizomatous *B. capense* (pp. 12, 49) appear in Fig. 13; but another form drapes lowland banks with fronds up to 2 m long (p. 55).

In *Blechnum patersonii*, which grows on steep, heavily shaded rocky places, the sterile fronds are coarse, bluish green, and not fully divided into separate leaflets, or they can even be undivided and strap-like. *B. vulcanicum* has triangular fronds which hang from steep banks.

Other kinds of *Blechnum* have much smaller fronds, generally less than 20 cm long. They include *B. fluviatile* and *B. lanceolatum* of moist, loose soil in the forest; *B. nigrum*, a fern with blackish green fronds which match the deep shade in which it grows; *B. banksii* which grows at the lower limit of land plants on coastal cliffs; and the small, creeping *B. pennamarina* which is a pioneer on stony ground.

Broadleaf. *Griselinia littoralis*

Broom, native. *Carmichaelia*

Browntop. *Agrostis tenuis*

Bryophytes (p. 16). Mosses and liverworts (q.v.)

Bulbinella. Onion-like plants of the lily family with racemes of yellow, regular flowers. *B. gibbsii* is a robust, 40 cm tall plant of alpine grasslands, whereas the much smaller *B. modesta* grows in pakihis.

Bulbophyllum pygmaeum (p. 16). An epiphytic orchid.

Bulrush. *Typha orientalis*

Buttercup. *Ranunculus*

Calceolaria, New Zealand. *Jovellana repens*

Calorophus minor (pp. 50, 71, 89, 118; Fig. 25). A rush-like plant with wiry stems of jointed appearance, abundant on wet heathland and pakihi. It is related to *Leptocarpus* (q.v.).

Caltha novae-zelandiae (p. 53). A small herb of poorly drained low-alpine grassland, with white, regular, five-petalled flowers and heart-shaped leaves with the lower lobes turned up folded forwards.

Calystegia. Plants with long, wiry stems, heart-shaped leaves, and largish flowers shaped like the bell of a trumpet. *C. soldanella* (p. 87) has pink flowers and stems that creep beneath coastal sand. *C. tuguriorum* is a white-flowered vine of coastal scrub, while the similar but larger *C. sepium* is an introduced weed common around settlements.

Cape pondweed. *Aponogeton distachyus*

Cardamine debilis. A slender cress with small, white, four-petalled flowers and narrow pods, found in shaded places such as beside forest tracks. A species of high-alpine talus is similar in its parts except that the whole plant is contracted into low, bright green tufts.

Carex. A large genus of leafy sedges with at least 27 species in and near Westland National Park. Most have bright green, hairless leaves, double-folded longitudinally into a ⋀⋀ shape. The leaves are arranged in three rows on the stems, in contrast to those of true grasses, which are in two rows.

Of the rhizomatous species, *C. coriacea* (p. 71; Fig. 31) is very abundant on damp river silt and shallow fertile swamps at low altitudes. The very similar *C. sinclairii* replaces it in the subalpine belt. *C. gaudichaudiana* (pp. 53, 74) has darker, narrower (often much narrower) leaves and a distinctive green and black pattern on its spikelets. It often dominates infertile swamps and ascends to the low-alpine belt. Another very slender sedge of infertile swamps, *C. echinata*, can be distinguished by the star-like arrangement of its spikelets. A diminutive rhizomatous sedge, *C. libera* (p. 109) has been found in low-alpine grassland on Mt. Fox. The rhizomes of *C. pumila* (p. 87; Fig. 33) ramify in coastal sand.

Several sedges, including *C. testacea* (p. 117), grow as wiry tussocks in lowland grassland. *C. solandri* (p. 11; Fig. 35) forms green tussocks in coastal forest. It is similar to *C. dissita* of swampy ground which, however, has black, oblong spikelets.

C. virgata is a metre-tall, dense tussock of lowland swamps and lake margins. It has a narrow, stiff inflorescence and lacks the characteristic "trunk" of its close relative, *C. secta* (p. 71).

C. pyrenaica (pp. 18, 99; Fig. 51) is a high-alpine species.

Carmichaelia (p. 30). The local species of native broom have small, scented, white flowers often streaked with violet. *C.* cf. *grandiflora* (p. 49; Fig. 19) is usually a pioneer on slips and river gravels. *C. arborea*, a taller broom with more slender and less flattened branchlets, grows on swampy ground and river banks, while the sprawling *C. nigrans* grows here and there on abandoned stony river beds. *C. petriei* (p. 17) is confined to dry parts of Otago and South Canterbury.

Carpha alpina (p. 53). A tufted sedge of poorly drained low-alpine grassland and piedmont cushion bogs, with feathered seeds.

Carpodetus serratus (p. 20, 122; Fig. 21). A small lowland and montane tree with marbled foliage and white flowers.

Cassinia vauvilliersii. A shrub composite of piedmont and subalpine scrub, with sticky twigs and close-set oval leaves 5-10 mm long that are green above and yellowish beneath.

Celery pine. *Phyllocladus alpinus*

Celmisia (p. 13, 98). A diverse genus of herbaceous and semi-woody composites. In most species, the white-rayed heads are carried singly on long stalks, and the leaves are clad in downy or satiny hairs, at least on the lower surface. There are 13 species in Westland National Park.

C. coriacea (pp. 15, 54; Fig. 47), the largest species, forms silvery clumps in openings in subalpine scrub and low-alpine grassland. *C. armstrongii* (p. 54) is similar in appearance and habitat, but the leaf blades are narrow and tapering (about 30-40 cm x 15 mm). *C. petiolata*, which forms smaller, looser tufts, is readily identified by its relatively long, purple leaf stalks.

Two very small tufted species are *C. gracilenta* (leaf blades 4-5 cm x 2-3 mm) of low-alpine grassland and the rather broader-leaved *C. graminifolia* which grows in piedmont infertile swamps and pakihis. *C. vespertina* is larger (leaf blades 7-10 cm x 3-5 mm), and grows in high-alpine grassland.

Another group has a sprawling habit, loosely covering large areas with springy stems. The most widespread of these is the subalpine and low-alpine *C. du-rietzii* (p. 54) which has grey, oblong leaves with fine marginal teeth. It is replaced in high-alpine grassland by the very similar *C. haastii* which has smooth leaf margins. *C. walkeri* (p. 121; Fig. 47) has narrow, triangular leaves. *C. bellidioides* (p. 54) is a rather rare species of moist crevices and has small, green, completely glabrous leaves.

C. hectori (p. 108; Fig. 50) is a singularly beautiful high-alpine plant in which the stems are contracted so that the foliage forms a silvery cushion. *C. sessiliflora* (p. 18; Fig. 50) forms mats and is one of the few celmisias with sessile flower heads. *C. glandulosa* grows in subalpine and low-alpine bogs and flushes. It is rhizomatous, and the oblong, glabrous leaves and flower stalks are very sticky.

Centrolepis ciliata (pp. 50, 89). A plant, related to the rushes, which forms small, round, moss-like cushions and grows in infertile swamps and acidic pools.

Cerastium holosteoides (p. 118; Fig. 28). A rather hirsute, biennial chickweed.

Chara. An alga described on p. 74.

Chenopod (p. 87). Slightly succulent herbs of saline and cultivated habitats, bearing a mealy coating on their leaves.

Chickweed. See *Cerastium, Sagina, Stellaria.*

Chionochloa (pp. 13, 18, 20, 118, 119, 123). A genus that includes the dominant grasses of the alpine belts. Most are large and tussock-forming. The spikelets (those illustrated in Fig. 50 are representative) are carried in open panicles.

C. pallens (pp. 13, 52, 53) dominates most of the low-alpine grasslands, and is recognisable by its pale midribs. *C.* cf. *rigida* (p. 53) tends to be subalpine on poorly drained ground and has very tough leaves that usually lack a distinctive midrib. *C. rubra* (p. 50; Fig. 17) has very narrow leaves with rolled-in margins, and the tussocks have a distinctly red sheen. It grows on piedmont heathland and on terraces in the Landsborough Valley.

C. cf. *flavescens* (p. 54), which has dark green leaves 1 cm wide, is an alpine species of steep bluffs and recent soils. *C. conspicua* is usually a pioneer on lowland slips and river banks. A tall, graceful grass, it is best distinguished from toetoe (*Cortaderia conspicua*) by having the stem bases oval rather than round and plumes that are much less dense.

C. crassiuscula (p. 53) is a smaller tussock of poorly drained alpine grassland. Its stiff, curved leaves tend to corkscrew at the tips during dry weather. The smallest species, which is the turf-forming, high-alpine *C. oreophila* (pp. 14, 18), is illustrated in Fig. 50.

Cirsium vulgare (p. 118). A tall, stout, biennial thistle. Other thistles in the area are the troublesome, rhizomatous "Californian" thistle, *C. arvense*, and two kinds of milk- or sow-thistle *(Sonchus).*

Claytonia australasica (p. 18). A delicate, glabrous creeping herb with narrowly oval leaves 1-2 cm long and 5 oval, spreading, white petals.

Clematis paniculata. A liane of lowland forest margins and woodland, with large, white starry flowers and plumed seeds.

Clover. See *Lotus, Trifolium.*

Club-moss. *Lycopodium*

Cockaynea laevis (p. 117; Fig.49). A grass forming patches in mountain valleys, distinguishable by its slender, nodding seed heads.

Collospermum (p. 11). A genus closely related to *Astelia.*

Colobanthus. Moss-like alpine herbs with narrow, pale green, glabrous, often bristle-pointed leaves and greenish flowers. *C. monticola* (p. 18) forms bristly cushions 2-5 cm across in dryish high-alpine sites, whereas the softer *C. canaliculatus* tends to grow in snow hollows. *C. affinis* forms loose mats in damp, gravelly places in the low-alpine belt.

Comb-sedge. *Oreobolus*

Composites. The daisy family which has flower heads composed of tightly packed, tiny florets. The latter are either regular "disc" florets which form the centre of the head or marginal, petal-like "rays". Either disc or ray florets are lacking in many genera.

Convolvulus. See *Calystegia*

Coprosma (pp. 104, 107). Shrubs of varied size and habit, distinguishable by their opposite leaves with pairs of small pits on the under surface, green male and female flowers on separate plants (see Fig. 19), and berries with two seeds, each of which is flat on one side and rounded on the other. Twenty-one species grow in Westland National Park.

All the coprosmas have smooth leaf margins, except for two species with minute serrations. One is *C. serrulata* which has leathery, round leaves 2-3 cm across and weak stems which scramble through low subalpine scrub. The other is the rhizomatous *C. crenulata*, which grows in poorly drained subalpine sites. Its oblong leaves are 6-10 mm long and notched at the apex.

C. lucida (p. 11; Fig. 6), abundant in coastal, lowland, and montane forest, has the largest leaves among the species of the district. *C. rotundifolia*, a tall shrub of fertile river flats, has thin, slightly hairy leaves 5-15 mm across that are round except where they are drawn into a point at the tip.

Remaining species have very small leaves and slender twigs which are often interlaced or divaricating. Erect species with more-or-less oval leaves include *C.* cf. *parviflora* which has white or red berries and occurs widely in forest, scrub, and swamp from the lowlands to the subalpine belt, and *C. ciliata* which has two forms. One is a tall shrub of forest and river flat shrubland, with sparsely hairy leaf margins and usually whitish berries that contain two seeds of unequal size and shape, while the other (pp. 19, 121), a low-alpine shrub with dark red berries.

C. propinqua (pp. 70, 89; Fig. 19) is a mainly lowland shrub with dark green, oblong leaves and blue, dark-speckled berries. *C. rhamnoides* (p. 11), of lowland and montane forest, has leaves which vary in size and shape from very narrow to broadly oval. The berries are dark red.

C. pseudocuneata is a tall subalpine shrub with yellowish green, narrow, pointed, rather close-set leaves. *C. rugosa* (Fig. 19) is a pioneer shrub of stony river beds and talus, with linear leaves and blue berries. *C. astonii* (p. 12) is a weak-stemmed shrub of upland forest, also with narrow leaves.

Four species have prostrate or scrambling stems. These are *C. brunnea* (p. 117; Fig. 27) of stony river beds; a similar plant that grows in infertile swamps; the red-berried *C. depressa* which grows in the undergrowth of subalpine forest and scrub; and the related *C. cheesemanii* which has orange berries and narrower leaves and is found on stony low-alpine sites.

The smallest coprosma, *C. pumila*, grows as dense, bright green mats in turfy alpine vegetation and usually has three seeds in each orange berry.

Coriaria arborea (p. 47; Fig. 20). A shrub or small tree that pioneers on moist, recent soils and ascends to the montane belt. The thick, succulent new stems that rise from ground level, the dark green leaves, and black, luscious-looking fruit are highly toxic. Two other species in the area are semi-woody and die to the ground each winter. Their racemes bear fewer, larger berries. In one (*C. sarmentosa*) the leaves are oval and 2-3 cm across; in the other (C. plumosa) they are only 2-4 mm across.

Cortaderia richardii (p. 70). A giant tussock grass that colonises river beds and lowland slips.

Cordyline australis. The familiar cabbage tree with thick branches bearing tufts of metre-long, strap-shaped leaves. It grows mainly in swamps, on river flats, and in coastal scrub. *C. indivisa*, which is unbranched and has much broader leaves, is generally montane. Several plants grow on the roadside on the Cook Saddle, just north of Fox Glacier village.

Corybas. Small orchids found mainly on shaded banks, with more-or-less heart-shaped leaves and long tapering petals that impart a spider-like appearance to the flowers.

Cotula (p. 109). A genus of composites that lack ray florets. The rhizomatous *C. squalida* (p. 117; Fig. 28) is typical and abundant in grassy places from sea level to the alpine zone. The coastal *C. dioica* and the high-alpine *C. pectinata* are similar, excepting that their leaves are less intricately divided. *C. coronopifolia* a coastal, non-creeping species, has bright yellow "buttons".

Craspedia. Herbaceous composites, mainly alpine, in which the flower stalks are capped by conspicuous, whitish, "pompom" heads that lack ray florets.

Crape fern. *Todea*

Crocosmia x *crocosmiifolia.* A garden escape described on p. 74.

Crown fern. *Blechnum discolor.*

Cyathea. One of our two genera of tree ferns, distinguished by flat fronds which have small, bead-like spore sacs on the lower surface and scales rather than hairs along the stalks. *C. smithii* (p. 11; Fig. 2) is the commonest species, recognised by its soft fronds which persist as a hanging skirt after their death. *C. medullaris* is described on p. 10. *C. cunninghamii* (p. 11) is similar but more slender and can best be distinguished from other tree ferns by the very thin trunks of the young plants. The prostrate *C. colensoi* is described on p. 12.

Cyathodes. Heaths with berries and white, tubular flowers. *C. fraseri* (p. 117; Fig. 27) is a rhizomatous dwarf shrub of stony river flats. The rest of the species have fine, white, longitudinal stripes on the backs of the leaves. The low-alpine *C. pumila* has much of the appearance of *C. fraseri* but forms closer, softer mats; *Pentachondra pumila* looks almost identical to *C. pumila,* but the leaves are green beneath. *C. empetrifolia* is a low, scrambling shrub of piedmont heathland, with linear leaves 2-3 mm long. *C. juniperina* is up to 2 m tall and well distinguished by its sharp, needle-like leaves up to 1 cm long. It grows mainly in open lowland and montane forest and tall scrub.

Cyperus ustulatus (p. 87). A tussocky coastal sedge with broad, green leaves and dark brown spikelets borne in clusters of dense, cylindrical spikes 3-5 cm long.

Dacrydium. Shrubs and trees of the podocarp family with more-or-less scale-like leaves, at least in the adult stage. *D. cupressinum* (pp. 11, 12, 20, 47, 50, 71, 86, 96, 97, 107, 111, 136; Fig. 5, 8) is the most abundant large tree in Westland. All the other species (Fig. 23) grow on leached, boggy soils. *D. colensoi* (pp. 50, 54, 71, 75) ranges from a small shrub to a straight-boled tree 15 m tall. In *D. biforme* (pp. 50, 54, 75) and *D. bidwillii* (pp. 50, 71) the juvenile and adult foliage differ markedly; the first species is the larger in stature, girth, thickness of twigs, and size of leaves.

D. intermedium (p. 50) has foliage rather like that of *D. cupressinum* excepting that it is yellowish green, and the tree is low and widely branching. *D. laxifolium* (p. 50), though so different in stature, is closely related. A natural hybrid between the two scrambles among low shrubs.

Dandelion. See under *Hypochoeris*

Dawsonia superba. A giant moss described on p. 12 (Fig. 8).

Dendrobium cunninghamii (pp. 16, 54; Fig. 2). A shrub-like epiphytic orchid with white or blue flowers more than 1 cm across.

Dendroligotrichum dendroides (p. 12; Fig. 11). A tall moss that grows mainly in upper montane forest.

Deschampsia caespitosa (p. 99). A tussocky swamp grass with panicles of small spikelets.

Desmoschoenus spiralis (p. 87; Fig. 33). A sand-binding sedge with conspicuous, golden green leaves.

Dianella nigra. A tufted forest lily with open panicles of white flowers and bright blue berries.

Dichondra brevifolia (p. 89; Fig. 34). A rhizomatous herb of coastal turf with small, heart-shaped leaves.

Dicksonia. Tree ferns with hairy stalks to the frond and spore sacs protected by recurved margins of the frond. The most abundant species, *D. squarrosa* (p. 11; Fig. 2), tends to grow in thickets in the forest understorey. *D. fibrosa,* which is rare in this district, has very thick trunks and, like *Cyathea smithii,* has a hanging skirt of dead fronds. *D. lanata* lacks a trunk and forms dense colonies in a few places in lowland and montane forest.

Discaria toumatou (p. 17). A divaricating shrub with needle-sharp spines that is abundant in eastern districts of the South Island.

Disphyma (p. 87). Trailing coastal plants with thick, succulent, triangular leaves.

Donatia novae-zelandiae (p. 50). A cushion plant with small white flowers that grows in very infertile bogs.

Dracophyllum. An important genus of heaths with tapering, grass-like leaves and small, white, bell-shaped flowers. *D. longifolium* (pp. 13, 52; Fig. 13, 15) is a shrub or small tree common in shrubland and heath forest from the piedmont area to the alpine tree limit. *D. uniflorum* (pp. 14, 121; Fig. 13) is a smaller shrub with dense, reddish foliage and flowers borne singly. *D. kirkii* (pp. 17, 54) grows espalier-like on alpine rocks, while *D. palustre* is a small, sparsely branched shrub of piedmont bogs.

The remaining species have much larger, recurved leaves and thick branches and are all subalpine. *D. traversii* (pp. 13, 52), the most widespread, is shown in Fig. 15. *D. fiordense* (pp. 54, 108; Fig. 15) is recognised by its erect, unbranched stems, while *D. menziesii* (p. 108) forms thickets of semi-prostrate stems bearing smaller heads of reddish leaves.

Drapetes. A genus of creeping semi-woody plants with greyish, overlapping, scale-like leaves and small white flowers. *D. lyallii* (p. 18; Fig. 50) forms soft, close mats in the high-alpine belt. *D. multiflorus* (p. 109) and *D. laxus* are larger plants of more open habit and found locally in subalpine and low-alpine grassland respectively.

Drosera (pp. 50, 54). Insect-catching plants of boggy ground. *D. binata* (p. 89; Fig. 25) and *D. stenopetala*, with strap-shaped leaves, grow at low altitudes. *D. arcturi*, also with strap-like leaves, is subalpine, while *D. spathulata*, with leaves spoon-shaped, is common over a wide altitudinal range.

Earina (pp. 16, 54). Epiphytic orchids with close-set, grassy leaves and racemes of scented, small, white flowers. *E. autumnalis* (Fig. 10) has broader leaves than *E. mucronata.*

Edelweiss, New Zealand. *Leucogenes*

Eelgrass. *Zostera*

Elaeocarpus. Tall trees with racemes of frilly-tipped white flowers and berries 10-15 mm long. *E. hookerianus* (p. 15; Fig. 4) is widespread, though seldom abundant, in lowland and montane forest and has a divaricating juvenile form very different from the adult. *E. dentatus* (p. 108; Fig. 4) is rare in the national park although abundant in North Westland. The leaves are larger and longer than those of *E. hookerianus* and have deep pits on the back against the midrib, as in *Coprosma.*

Eleocharis. Sedges with a single spikelet terminating the stem. *E. sphacelata* (p. 74) is of more local occurrence than the much smaller *E. acuta* (p. 74; Fig. 31) which grows on damp ground as well as in swamps and lakes.

Elodea canadensis (p. 75; Fig. 30). A submerged water weed rooted in silty lake and stream bottoms.

Entolomma hochstetteri. (p. 12).

Elytranthe. A mistletoe, described on p. 108.

Epilobium (pp. 20, 49, 70, 99). Herbs with leaves mainly in opposite pairs, flowers with four notched petals, and narrow pods with fluffy seeds. There are about 19 species in the park, mostly growing in places where there is little competition from other plants. The more-or-less erect *E. glabellum* (p. 18; Fig. 27) and the prostrate *E. brunnescens* (Fig. 46), which has round, shiny leaves lying flat on the ground, are both abundant on loose, stony ground from the lowlands to the alpine limits of vegetation. *E. alsinoides*, with prostrate stem bases rising to erect, flowering tips, is common in short grassland over a wide range of altitude. *E. chlorifolium* is a larger plant of similar habit found mainly in openings in subalpine scrub.

Everlasting daisy. See *Helichrysum*

Euphrasia. Belonging to the same family as hebes and veronicas, these mainly alpine herbs are semi-parasites, producing suckers that connect their roots to those of other plants. *E. zelandica* (Fig. 47) and *E. cockayniana* are discussed on p. 109. *E. disperma*, which grows in infertile swamps around Okarito, has the tubular part of the corolla elongated to about 25 mm.

Eyebright. *Euphrasia*

Fat hen. See Chenopod

Fescue, Chewing's. *Festuca rubra*

Fescue, tall. *Festuca arundinacea*

Festuca. Tufted or tussocky grasses with panicles bearing slightly flattened spikelets with short bristles. Most of the species have very fine leaves with tightly inrolled margins. Chewing's fescue (*F. rubra*) (p. 117) is an introduced perennial pasture grass abundant on lowland river flats. (The rather similar *Vulpia myuros*, or hair grass, differs in being annual and having long-bristled spikelets.) A subalpine form of *F. rubra*, with bluish stems, leaves, and spikelets, is probably native. *F. matthewsii* is a native tussock common on montane and subalpine river flats. *F. arundinacea* (pp. 70, 116), in contrast to the preceding species, is a broad-leaved introduced grass, with flowering stems 1-2 m tall, that grows on damp silty ground and grazed swamps.

Filmy fern. See Hymenophyllaceae

Flax. See *Phormium*

Forget-me-not. *Myosotis*

Forstera. Herbs with thick, pale- or bluish-green leaves 5-8 mm long, overlapping along more-or-less prostrate stems, and five-petalled flowers on slender stalks. *F. sedifolia* and an unnamed species (p. 108) grow in subalpine and low-alpine grassland, whereas *F. tenella*, which has thinner, spreading leaves, grows also in moist, shaded, gravelly places on the floors of moun-

tain valleys where its leaves can be up to 15 mm long.

"Foxglove", native. *Ourisia*

Freycinetia banksii (pp. 11, 19, 70, 86; Fig. 2). A robust lowland liane.

Fuchsia excorticata (pp. 20, 54, 119, 122; Fig. 2). A small, deciduous tree which forms a major nectar source for birds. The related *F. perscandens* is a weak-stemmed shrub that grows on lowland forest margins.

Gahnia. Large, tussocky sedges with bright green leaves. The ripe seeds hang from the panicle in a tangle of threads. Of the two species with harsh, cutting leaves, *G. xanthocarpa* (p. 70) has open drooping panicles borne on stems up to 3 m tall, whereas the smaller *G. rigida* (p. 71; Fig. 24) has narrow, rigidly erect panicles. The still smaller *G. procera (p. 50; Fig. 2*

panicles. The still smaller *G. procera* (p. 50; Fig. 24) has smooth leaf margins and grows in forests on leached soils from the lowlands to the subalpine belt.

Galium. Creeping or climbing herbs with leaves arranged in whorls of four along the stem. The main species are the introduced *G. palustre* (p. 117; Fig. 30) and the native *G. perpusilla* which has stems 1-4 cm tall forming loose mats in lowland and montane grassy places.

Gaultheria. A genus related to heaths but with leaves that are broad and net-veined rather than grassy or scale-like. *G. rupestris* is an attractive shrub with thick, serrate leaves 1.5-3 cm long and copious panicles of small, white, bell-shaped flowers. *G. depressa* is a creeping species, mainly subalpine and low-alpine, with edible, white "berries" (really swollen sepals) 1 cm across. *Pernettya* is a very closely related genus. *P. macrostigma* (p. 117; Fig. 27) is a pink-berried dwarf shrub forming tangles on stony river flats, while *P. alpina* is similar to *G. depressa* but neither sepals nor capsules swell into succulent berries. It forms low mats in the high-alpine belt.

Gentiana. The New Zealand species have generally white, cup-shaped, five-petalled flowers carried in more-or-less dense inflorescences, on a stem rising from the leaf rosette. The following species names are only tentative. *G.* cf. *divisa* is an especially beautiful plant of high-alpine stony herbfield, with densely massed flowers rising from a single rosette. *G.* cf. *bellidifolia* forms small matted patches, and there are only one to three large flowers on each stalk. In *G.* cf. *patula*, which grows mainly in openings in subalpine scrub, the flowering stems are up to 30 cm tall and bear leafy umbels of up to 10 flowers. *G.* cf. *spenceri* which grows in piedmont grassland is similar excepting that its leaves and stems are reddish and the petals pinkish blue towards the base.

Geum parviflorum. A mainly low-alpine herb with rosettes of hairy, pinnate leaves with large terminal segments and panicles of white, strawberry-like flowers.

Glasswort. See *Salicornia*

Gleichenia. Ferns of infertile soils in which the frond is umbrella-like through several forkings of the stalk. *G. cunninghamii* (p. 49; Fig. 24) grows mainly in forest and *G. circinata* (pp. 50, 118; Fig. 24) in shrubland and heathland.

Glossostigma elatinoides (p. 75). A small, rhizomatous plant of shallow water and mud, with opposite, oval, long-stalked leaf-blades 4-8 mm long. The tiny, five-petalled flowers are light-blue in Westland plants.

Glyceria fluitans. An introduced grass of wet ground, pools, and sluggish streams, with leaves that tend to lie floating on the surface of the water.

Gnaphalium (p. 98). Herbaceous composites falling into two very different groups. One includes weedy species of open places, some of which form patches of flat-lying, more-or-less woolly leaves. The individual heads are tiny and inconspicuous but are usually grouped into clusters surrounded by leaf-like bracts. *G. audax* is the commonest of these species.

The other group is more striking. The heads are much larger and surrounded by persistent, petal-like bracts like those of *Helichrysum bellidioides* (q.v.) with which they would be classed but for a botanical technicality, but, unlike *H. bellidioides*, the flower stalks are branched and bear several heads. The leaves are white beneath and closely overlap along elongated, sprawling stems. *G. trinerve* (pp. 55, 87), the largest, grows abundantly on steep coastal and inland cliffs.

Gorse. *Ulex europaeus*

Grass. See *Agrostis, Agropyron, Ammophila, Anthoxanthum, Chionochloa, Cockaynea, Cortaderia, Festuca, Glyceria, Hierochloe, Holcus, Lachnagrostis, Lolium, Notodanthonia, Poa, Trisetum.*

Griselinia littoralis (pp. 12, 14, 49, 119; Fig. 3). A widely distributed tree with light green leaves and an irregular, rough-barked trunk. *G. lucida* (pp. 11, 16; Fig. 3) is an epiphytic shrub.

Gunnera (p. 47). Creeping plants with erect panicles of usually separate male and female flowers lacking obvious petals and sepals. The

orange-berried *G. dentata* (Fig. 27) grows on flood plains. *G. monoica* (pp. 55, 87) has more dissected, shinier leaves and white berries. It is abundant both on stony flood plains and trailing down coastal and inland cliffs.

Haastia sinclairii (p. 109). A composite of high-alpine talus that forms loose clumps of sprawling stems hidden by woolly leaves.

Hall's totara. *Podocarpus hallii*

Haloragis erecta. A coastal tall, semi-woody herb with opposite, serrate, elliptical leaves up to 7 cm long and clusters of small green flowers. Two very small, rhizomatous species grow in grassy or boggy inland places.

Heath. In a restricted sense, plants of the genus *Erica*, which have very small, hard leaves and small, bell-like flowers. More broadly, the term includes also the related southern heaths — local genera being *Archeria, Dracophyllum, Cyathodes,* and *Pentachondra* (q.v.). In another sense, heath is used to describe vegetation in which heath-like plants predominate (p. 50).

Hebe (pp. 17, 98, 104). Shrubs with leaves arranged in opposite pairs, to form four regular rows along the twigs. *H. salicifolia* (pp. 49, 86; Fig. 20) is an abundant lowland and montane tall shrub with racemes of pale lilac flowers. The coastal *H. elliptica* (p. 87; Fig. 34) has shorter leaves and flowers a deeper shade of blue. *H. subalpina* is montane and subalpine, with white flowers and narrow-elliptical leaves 2-4 cm long. *H. odora* has hard, glossy, broad-oval leaves up to 2 cm long and grows mainly in subalpine grassland.

H. treadwellii (pp. 17, 110) and *H. ciliolata* (p. 17; Fig. 51) are dwarf shrubs that ascend to the high-alpine belt. The former is easily recognised as a *Hebe*, while the latter has leaves that are almost scale-like. The true "whipcord hebes" (p. 109) have still smaller leaves pressed tightly to the stem. Another unusual *Hebe* is a small shrub of low-alpine grassland, *H. macrantha,* which has notched leaves and white flowers about 1 cm across.

Hectorella caespitosa (pp. 18, 98; Fig. 50). This conspicuous high-alpine plant consists of rosettes of leaves packed into large, flat cushions which in February are nearly hidden by creamy flowers.

Hedycarya arborea (pp. 11, 14; Fig. 5). A small lowland tree, in which each cluster of "berries" develops from a single greenish-white flower.

Helichrysum bellidioides (p. 121; Fig. 47). An everlasting daisy, abundant in stony grassland from the lowlands to the alpine belt, with single heads surrounded by white bracts. *H. filicaule*, a smaller plant of stony flats, has its leaves in two rows.

Hieracium praealtum. See under *Hypochoeris.*

Hierochloe (p. 117). Grasses with scented leaves and panicles of flat, nodding, shining spikelets. The species range from lowland swamp and heathland to low-alpine grassland.

Himalayan pea. *Parochetus communis*

Histiopteris incisa (p. 119; Fig. 6). A large rhizomatous fern with flat, pale green leaf segments.

Hinau. *Elaeocarpus dentatus*

Holcus lanatus (pp. 116, 117). A common introduced grass with furry leaves and panicles contracted into whitish heads up to 10 cm long.

Hoheria glabrata (pp. 13, 54, 108, 119). An abundant small subalpine tree described on p. 13.

Hook-grass. *Uncinia*

Horopito. *Pseudowintera colorata*

Hydrangea (p. 117). A well-known garden shrub.

Hydrocotyle. Small, creeping, aromatic herbs of the carrot family with thin, round leaves. *H. novae-zelandiae* (pp. 117, 119, 121), in its variety *montana*, has smooth, shining leaves and is abundant in browse-induced turf from the lowlands to the alpine zones. Another variety, with fine hairs on the leaves, is mainly lowland on wet ground. Another lowland species, *H. moschata,* has deeply dissected leaves.

Hymenanthera alpina. A depressed shrub of low-alpine rocky crests with thick, almost spiny twigs. The white berries are borne on the lower side of the more-or-less prostrate branches. *H. angustifolia* is a tall, divaricating, small-leaved shrub found rarely on lowland river flats.

Hymenophyllaceae (pp. 12, 16). The filmy ferns are described on p. 12. The spore sacs are borne on stout bristles on the frond margin; in the genus *Hymenophyllum* each bristle is protected by a two-lipped pouch, whereas in *Trichomanes* it projects from a tubular membrane. Species range in size from the tiny *H. minimum* (p. 87; Fig. 34) to *H. dilatatum* which has hanging fronds up to 40 cm long. Most species have creeping stems, but *H. pulcherrimum* and *T. strictum* are tufted. Typically, filmy ferns are epiphytic in lowland and montane forest, but *H. demissum* (Fig. 8)

and *H. bivalve* carpet the forest floor, and several species including *H. multifidum* can grow on sheltered alpine rocks. See also *Trichomanes reniforme.*

Hypochoeris radicata (p. 118). Probably the most abundant of the dandelion-like plants in the park, this has rosettes of rough leaves and branched, solid stalks. *Hieracium praealtum* (p. 118), also very common, is taller and the leaves are greyish and very hairy. Others include the true dandelion (*Taraxacum officinale*) with single heads borne on hollow stalks; its native cousin *T. magellanicum* which is found mainly on moist, subalpine slopes; and the narrow-leaved *Microseris radicata,* found in montane swamps and also native.

Hypolepis (p. 119). Rhizomatous ferns with very finely divided, slightly hairy fronds that die down each winter. *H. millefolium* (pp. 54, 121) is abundant in the subalpine and low-alpine belts. *H. rufobarbata* grows in forest at lower altitudes and has smaller fronds with brown, bristly hairs on the stalk.

Hypsela rivalis. See under *Pratia.*

Ice-plant. *Disphyma*

Impatiens glandulifera. A garden escape described on p. 117.

Inaka. *Dracophyllum longifolium*

Isoetes alpinus. A submerged water plant described on p. 74.

Jointed rush. *Leptocarpus similis*

Jovellana repens (p. 108). A creeping herb of wet, shaded, gravelly banks. The corolla is white with unequal upper and lower "lips" opening from an inflated "throat".

Juncus. The true rushes which differ from grasses and sedges in having regular flowers with six scale-like sepals and petals. Some of the species, like the abundant native *J. gregiflorus* and *J. sarophorus,* and the introduced *J. effusus,* are large, leafless tussocks that grow in damp lowland grassland and shallow swamps.

A second group has leaves that are round or oval in cross section and have internal partitions. *J. articulatus* (pp. 70, 117; Fig. 31) is abundant in swamps, pools, and sluggish streams. Similar introduced species are the larger *J. acuminatus* and the densely tufted *J. canadensis.* A much smaller rush *J. novae-zelandiae,* with conspicuous, black seed capsules, grows in montane and subalpine seepages and swamp margins.

The third group has flat, grass-like leaves. *J. tenuis* (p. 118; Fig. 31) grows as tough, wiry tufts, whereas the native *J. planifolius* of lowland pakihis has wider, softer leaves. *J. antarcticus* is a rare mat-forming plant of subalpine flushes, with close-packed, firm, pointed leaves 2-3 cm long.

Kahikatea. *Podocarpus dacrydioides*

Kaikawaka, *Libocedrus bidwillii*

Kaikomako. *Pennantia corymbosa*

Kamahi. *Weinmannia racemosa*

Kauri. *Agathis australis*

Kawakawa. *Macropiper excelsum*

Kidney fern. *Trichomanes reniforme*

Kiekie. *Freycinetia banksii*

Koromiko. *Hebe salicifolia*

Kowhai. *Sophora microphylla*

Lachnagrostis. See under *Agrostis*

Lancewood. *Pseudopanax crassifolius*

Lanternberry. *Luzuriaga parviflora*

Langenifera. Creeping daisies of lowland and montane grazing places. *L. petiolata* (referred to as *Lagenophora pumila* in standard floras) is the main species. It is similar to the common introduced lawn daisy *Bellis perennis* but is more slender, with hairer, longer-stalked leaves.

Laurelia novae-zelandiae. A large, broad-leaved tree of wet ground that grows north of lat. 42°.

Lawyer. *Rubus* (native species)

Leatherwood. *Olearia colensoi*

Lepidosperma australe. A leafless sedge of piedmont heathland and pakihis, with distinctive square stems.

Lepilaena bilocularis. A submerged flowering plant described on p. 74.

Leptocarpus similis (pp. 75, 89; Fig. 35). A leafless rush-like tussock, with stems of jointed appearance, that grows on the shores of tidal lagoons and freshwater lakes, and less frequently, in infertile swamps.

Leptospermum scoparium (pp. 20, 50, 54, 71, 118). A shrub or small tree with firm, pointed leaves about 5 mm long, papery bark, white five-petalled flowers, and woody seed capsules. It is abundant on leached soils.

Leucogenes (p. 98; Fig. 46). Creeping or tufted everlasting daisies of alpine rock crevices, with silver grey leaves and flower heads surrounded by conspicuous, white, woolly, petal-like bracts. The Westland plant is *L. grandiceps.*

Libertia. Herbs with grassy leaves and panicles of white starry flowers. *L. pulchella* is a delicate, tufted little plant, with flower stalks only 10-20 cm tall, that grows on mossy forest floors. The much larger *L. ixioides* grows on the banks of tidal creeks.

Libocedrus bidwillii (pp. 12, 14, 15, 107, 111; Fig. 13). A cypress with a strongly tapering trunk, stringy bark, and conical crown.

Lichens (pp. 14, 17, 54, 86; Fig. 8, 51). Symbiotic plants of varied hues in which a fungal body encloses and is supplied with sugars photosynthesised by microscopic algae. They are found encrusting or tufted on bark, rocks, twigs, or sometimes soil.

Lilaeopsis (pp. 74, 75). A small umbellifer of wet ground and water, in which the leaves are reduced to soft, light green jointed midribs.

Liverworts (pp. 12, 20). Small, spore-bearing plants mainly of the forest interior. Some closely resemble mosses (to which they are related), while others are flattened platelets (Fig. 21) with a glossy green upper surface and a lower surface attached to the soil by fine threads.

Lobelia anceps (p. 87). A loosely tufted herb with stems 15-25 cm long, leaves varying from broad-oval at the base of the stem to narrow elliptical higher up, and small blue flowers.

Lolium perenne (p. 116). The most commonly sown grass of New Zealand pastures, with rather rough leaves and heads with spikelets alternating in two rows.

Lotus pedunculatus (pp. 47, 70; Fig. 28). An abundant, introduced, pioneering, clover-like plant.

Luzula. Plants in the rush family, but differing from *Juncus* (q.v.) in that their grass-like leaves are hairy. The main species in the park are high-alpine plants (*L. pumila* and *L. colensoi*) that form rounded cushions 2-4 cm across, the broad-leaved, tufted *L. banksiana* which grows mainly on eroding ground in low-alpine grassland, and the introduced *L. congesta* of lowland grassland.

Luzuriaga parviflora (p. 16). An epiphyte illustrated in Fig. 10, with white flowers and berries.

Lyallia kerguelensis (p. 99). The only species of a genus confined to Kerguelen Island.

Lycopodium. Wiry-stemmed relatives of the ferns. The leaves are yellowish and scale-like, and those that bear spores are usually arranged into distinct "cones". The species of the park are *L. australianum*, a tufted plant of alpine fellfield; *L. fastigiatum*, a grassland species in which erect, branched stems with imbricating leaves rise from underground stems; the similar but much smaller *L. ramulosum* of infertile swamps and pakihis; *L. varium*, a tufted species which usually grows as a hanging epiphyte; and two robust plants of lowland and montane scrub and open forest, the creeping and rooting *L. scariosum* and the scrambling *L. volubile* (p. 55; Fig. 9), both of which have their leaves lying in a flattened plane along the branchlets.

Macropiper excelsum (p. 11). A shrub, coastal in the South Island, recognisable by its heart-shaped leaves and catkin-like inflorescences.

Mahoe. *Melicytus*

Mamaku. *Cyathea medullaris*

Manuka. *Leptospermum scoparium*

Marbleleaf. *Carpodetus serratus*

Marsippospermum gracile (p. 18). An alpine representative of the true rushes (see *Juncus*), with smooth, shining, dark-green, cord-like stems and leaves.

Marram. *Ammophila arenaria*

Matai. *Podocarpus spicatus*

Matipo. *Myrsine australis*

Mazus radicans. A herb of grassy lowland and montane clearings, with rosettes of oblong, spotted leaves and white, blue-spotted flowers with yellow throats.

Melicytus ramiflorus (pp. 47, 49, 54, 86, 123; Fig. 22). A small lowland and montane tree with brittle twigs bearing flowers or fruit along their length. The rather scarce *M. lanceolatus* has narrower leaves.

Mentha cunninghamii. A small, white-flowered, weak-stemmed herb, often abundant in montane and subalpine grassland, that reveals its identity by a strong peppermint smell.

Metrosideros. An important genus of trees and lianes, with opposite leaves, flowers in which the numerous stamens are more showy than the petals, and a tendency to produce aerial roots from the stems. The three lianes in the park are listed on p. 12. *M. fulgens* (pp. 12, 14; Fig. 8, 10) has the largest leaves and showy red flowers. On the lower surfaces of its leaves *M. perforata* (pp. 12, 86; Fig. 8) has glandular

dots which distinguish it from the more abundant *M. diffusa;* both these are white-flowered.

The southern rata tree (*M. umbellata*) (pp. 11, 12, 14, 49, 54, 86, 122; Fig. 11) is the floral emblem of Westland, in fact if not formally. It is also valued for its copious nectar and the excellence of the firewood. The flowers vary through shades of red, with occasional trees bearing yellow or orange blossom. Most trees flower between November and March, and intensity of flowering varies from year to year. *M. robusta* (p. 11), a large tree often with epiphytic beginnings, extends southwards to Lake Mahinapua near Hokitika.

Microlaena avenacea (p. 119; Fig. 11). One of the few forest grasses in the park, characterised by broad, flat, pale green leaf-blades. *M. colensoi* (p. 121) is a loosely tufted alpine species with pale leaves tapering from a base about 3-4 mm wide.

Microseris radicata. See under *Hypochoeris.*

Microtis unifolia (p. 117; Fig. 28). Common in open places. The only local orchid which could be mistaken for it is *Prasophyllum colensoi* which has fewer, darker flowers twisted so that the "hood" is below the "lip".

Milfoil. *Myriophyllum.*

Mimulus repens. Described on p. 88.

Mistletoe. See *Elytranthe*

Miro. *Podocarpus ferrugineus*

Montbretia. *Crocosmia* x *crocosmiifolia*

Mosses (pp. 12, 16, 18, 20, 53, 87). Generally small plants, with thread-like stems, scale leaves, and spore-capsules borne on delicate stalks. See also *Dawsonia, Dendroligotrichum, Polytrichadelpus, Rhacomitrium, Sphagnum, Weymouthia.*

Mount Cook lily. *Ranunculus lyallii*

Mountain daisy. *Celmisia*

Mountain holly. *Olearia ilicifolia*

Muehlenbeckia australis. A vine, abundant in forest margins and openings, with heart-shaped or rounded leaves, panicles of small green flowers, and sepals that swell to enclose the ripe fruit in a white succulent "berry". Like the docks and sorrels to which it is related, a papery sheath encloses the stem above the point of attachment of each leaf. *M. axillaris* has small, oblong leaves, short, slender twigs, and stems that creep under the surface enabling it to act as a pioneer on gravelly fans and flood plains.

Myosotis caespitosa (pp. 70, 117). An introduced water plant with the deep blue flowers characteristic of northern hemisphere forget-me-nots. The native species (p. 18) are mainly white-flowered alpine herbs of loose stony soils (e.g. *M.* cf. *lyallii*) or rock crevices (*M. suavis*), although the species illustrated (*M. forsteri*, Fig. 51) grows in moist gravelly places at lower altitudes. *M. macrantha* is a handsome, erect herb of bare subalpine moraines and stony fans, with flowers in shades of blue, yellow, and mauve.

Myriophyllum. The description on p. 74 refers to submerged milfoils of lakes and streams (*M. propinquum, M. elatinoides,* and the larger *M. robustum*). *M. pedunculatum* (p. 89) is turf-forming in coastal marshes.

Myrsine (p. 107). Woody plants with gland-dotted leaves and blue berries. *M. australis* (p. 11; Fig. 5) and *M. salicina* (p. 108; Fig. 5) are small lowland or lower-montane trees. *M. nummularia* is a creeping subalpine and low-alpine dwarf shrub with reddish, round leaves. The tall shrub *M. divaricata* (p. 12; Fig. 12) has small, obcordate leaves and weeping, divaricating branchlets.

Neomyrtus pedunculata (p. 11). Divaricating shrub with opposite, greyish green leaves, square twigs, and white flowers.

Nertera (pp. 12, 119). The common species of the forest floor are *N.* cf. *dichondraefolia* (Fig. 7) and *N. depressa* which has smaller leaves without hairs. *N. balfouriana* of subalpine bogs has orange pear-shaped berries, while *N. setulosa* (p. 117), a hairy-leaved species of valley grasslands, has dry capsules instead of berries.

Nettle. *Urtica*

Nitella (pp. 74, 88). A large freshwater alga described in the text.

Nothofagus (pp. 13, 98, 104). Southern hemisphere beeches. The New Zealand species differ from the familiar European *Fagus sylvatica* of city parks in their small, evergreen leaves and small nuts. *N. menziesii* (pp. 13, 15, 20, 47, 53, 54, 97, 98, 104, 108, 111; Fig. 13) is the only species in the national park.

Notodanthonia. Tufted grasses that, like their larger relatives the chionochloas (q.v.), have panicles of hairy spikelets and a tuft of hairs where the leaf sheath meets the blade. The main species are *N. gracilis* which grows on stony flats and *N. setifolia,* a grass with very fine, yellowish green leaves that grows in stony or browse-damaged alpine grassland.

Olearia. The largest of the three genera of shrub-daisies in Westland National Park. Most species

have clusters of small heads with white rays and leaves that are downy or silky beneath. *O. avicenniaefolia* (pp. 49, 86; Fig. 19) is a stringy-barked shrub or small tree of gravelly soils of coastal talus, river flats, and moraines. *O. lacunosa* (p. 13; Fig. 14), the holly-like *O. ilicifolia* (pp. 14, 15, 119; Fig. 14), and *O. arborescens*, with oval leaves 4-6 cm across and satiny beneath, are mainly subalpine shrubs or small trees with papery bark which hybridise readily.

O. nummularifolia is a tall subalpine shrub with sticky buds and hard, round or oblong leaves 4-6 mm across. *O. moschata* (p.121; Fig. 14) is a high-altitude, scented shrub less than 1 m tall. The uncommon small tree *O. lineata* grows on river flats and has square twigs and soft, very narrow leaves up to 25 mm long, whereas the closely related *O. virgata* has oval leaves and grows in swamps.

O. colensoi (pp. 13, 16, 53; Fig. 14, 15) has relatively large, purplish heads without rays.

Orchids (pp. 12, 16, 99). Our orchids are far less conspicuous, and in lesser variety, than those of neighbouring lands in the Pacific, although their flowers are quite as intricate. See *Aporostylis, Bulbophyllum, Dendrobium, Earina, Microtis, Pterostylis, Thelymitra.*

Oreobolus (pp. 50, 53, 54). Small, cushion-forming sedges with rudimentary spikelets almost hidden among the leaves which lie in two rows. They grow in grassland and bog on wet, podzolised soils of the piedmont plateaux and the subalpine and low-alpine belts. *O. pectinatus* is illustrated (Fig. 25); in the other species the comb-like arrangement of the leaves is less obvious.

Ourisia. Alpine and subalpine herbs with large, white flowers with five unequal petals. The lower leaves are usually in rosettes, the upper opposite or in whorls. *O. macrocarpa* (p. 54), with shining heart-shaped leaves and flowering stems up to 50 cm tall, is one of the most striking mountain plants of the park. *O. crosbyi* is a more delicate species with furry leaves and is found on banks in the upper forest, while *O. caespitosa* and *O. sessilifolia* are mat-forming, the former glabrous and mainly low-alpine, the latter furry and high-alpine.

Oxygen weed. *Elodea canadensis*

Parahebe. Semi-woody plants very similar to *Hebe* (q.v.). *P. lyallii* with dull green, finely serrate leaves and *P. linifolia* with bright green, close-set leaves, rather like those of *Hebe ciliolata* but lacking the marginal hairs, both grow on stony river flats and fans. *P. linifolia* also extends to alpine rock crevices. *P. birleyi* (p. 14; Fig. 51) is a densely hairy, compact little plant.

Parochetus communis. Described on p. 117.

Parsonsia heterophylla. A liane with elliptical, smooth, marginal adult leaves, panicles of white flowers, and hanging pods 15 cm long containing seeds with tufts of long hairs.

Pate. *Schefflera digitata*

Pennantia corymbosa (p. 70; Fig. 30). A small lowland tree with dark green leaves and panicles of small white flowers.

Pentachondra pumila. See under *Cyathodes.*

Pepperwood. *Pseudowintera colorata*

Pernettya. See under *Gaultheria*

Phormium tenax (pp. 71, 74, 75, 86). The well-known native fibre plant which grows as huge tussocks on swampy lowlands. The sword-like leaves are 2-3 m tall, and the dark red, nectar-rich flowers are borne on tall stalks known as korari. *P. cookianum*, a shorter species with more slender korari, is mainly subalpine and low-alpine but also grows on rocky coasts south of Paringa.

Phyllachne colensoi. A hard, bright green, alpine cushion plant with small, thick leaves and white flowers.

Phyllocladus alpinus (pp. 49, 74; Fig. 23). A small podocarp with whorls of flattened, leaf-like branchlets.

Phymatodes diversifolium (p. 49). A creeping and climbing fern with bright green fronds, up to 40 cm long, which vary from strap-shaped to broad and deeply lobed without being divided into separate leaflets.

Phytophthora (p. 112). A genus of soil fungi including strains that are pathological to some forest trees.

Pigeonwood. *Hedycarya arborea*

Pimelea prostrata (p. 117). The white berries show that the resemblance to *Hebe* imparted by the four-rowed arrangement of the leaves is only superficial — in fact it is related to *Drapetes* (q.v.). *P. oreophila*, similar but with slightly hairy leaves, is found occasionally in low-alpine grassland.

Pingao. *Desmoschoenus spiralis*

Pink pine. *Dacrydium biforme*

Pinus radiata (p. 47). A three-needled pine introduced from California, this is now the major timber tree of New Zealand.

Pittosporum colensoi. A small lowland and montane tree with elliptical wavy-edged leaves about 8 cm long, very dark mauve flowers, and woody capsules that open to reveal sticky seeds. *P. crassicaule* is a thick-stemmed, divaricating shrub with small, lobed leaves, growing in scrub in the subalpine belt and the piedmont heathlands. Superficially it is similar to juvenile *Elaeocarpus hookerianus* (Fig. 4), but the flowers and fruit reveal the true affinities.

Plagianthus betulinus (pp. 47, 70; Fig. 29). The tallest native deciduous tree, whereas the coastal *P. divaricatus* (p. 89; Fig. 34) is a small-leaved, twiggy shrub. The bark of both species contains tough, lace-like fibre.

Plantago. A genus of "flatweeds", generally with dense, long-stalked spikes of small green flowers rising from a rosette of leaves. Species include the introduced plantains of lawns and pasture (*P. lanceolata, P. hirtella*) and five smaller, patch-forming native species most of which are subalpine and alpine; *P. raoulii* is probably the commonest of these.

Poa. An important genus of grasses with panicles of flattish spikelets with very short awns and generally folded leaves with boat-shaped tips. *P. cockayniana* (pp. 15, 54; Fig. 49) is abundant on steep montane and subalpine slopes, either as distinct tussocks or as thick, trailing mats. It is scarcely to be distinguished from the silver tussock (*P. laevis*, p. 117) of lowland river flats or the coastal *P.* cf. *anceps* (p. 87). *P. colensoi* (pp. 14, 18; Fig. 49) forms short, bluish green turf in the alpine belt. *P. novae-zelandiae* (p. 18), a grass with large, bluish spikelets, is as variable as the habitats it occupies — short, tufted forms grow on high-alpine talus and, at the other extreme, long-stemmed forms trail down the sides of waterfalls at lower altitudes.

Introduced poas include the tufted weed *P. annua* and the rhizomatous "Kentucky bluegrass" (*P. pratensis*).

Podocarp. An important family of conifers, described on p. 11. See also *Dacrydium, Phyllocladus, Podocarpus.*

Podocarpus hallii (pp. 11, 12, 14, 111; Fig. 7). One of four species with very similar fruit and leaves. It is (or was before recent decimation — p. 123) a dominant tree in many montane forests. *P. totara* var. *waihoensis* (pp. 8, 70, 96, 109, 111, 116), with narrower, sharper leaves, replaces it on lowland river flats, whereas the sprawling shrub *P. nivalis* (pp. 16, 18; Fig. 13), which hybridises with *P. hallii*, is subalpine. The taller shrub *P. acutifolius* (p. 109) forms thickets in a few places on the piedmont plateaux.

The remaining species of *Podocarpus* have hard, grey bark which flakes off as chips. *P. spicatus* (pp. 8, 70, 96, 111, 116; Fig. 29) has short, blunt "needles" and catkins and fruit borne in spikes. In *P. ferrugineus* (pp. 11, 12, 86, 111; Fig. 7) the dark green leaves are in two rows and the plum-like fruits are solitary. *P. dacrydioides* (pp. 8, 70, 96, 107, 116, 118; Fig. 29) differs from all the others in that the adult leaves are scale-like and pressed to the twig.

Pokaka. *Elaeocarpus hookerianus*

Polystichum vestitum (pp. 12, 54, 119, 121, 123; Fig. 13). A large fern, described on p. 12, which is abundant in the forests of higher altitudes. *P. cystostegia*, with softer, light green fronds, grows among alpine rocks.

Polytrichadelphus magellanicus (p. 55). A moss that colonises bare ground, forming loose carpets of erect, unbranched, wiry stems. The narrow, pointed leaves are distinctly ribbed.

Pond fern. *Azolla*

Potamogeton. Water plants described on p. 74. *P. oblongus* and *P. cheesemanii*, the two most abundant species, can be distinguished by the former having more than 12 longitudinal veins in its leaves, and the latter fewer than 6.

Prasophyllum colensoi. See under *Microtis*

Pratia angulata (pp. 116, 119). A creeping plant found abundantly on moist ground from sea level to the low-alpine belt. The alpine *P. macrodon* can be distinguished by its creamy, sweet-scented flowers. *Selliera radicans* (p. 89) which grows in coastal turf also has white flowers split down one side. The aquatic *Hypsela rivalis* (p. 75) is related to *Pratia*, but its flowers are tiny and not obviously split.

Pseudopanax. Small trees and shrubs with greenish flowers in umbels. *P. colensoi* var. *ternatus* (pp. 11, 12, 104, 119; Fig. 12) is distributed from sea level to tree limit. *P. simplex* (p. 12; Fig. 12) is abundant in higher-altitude forests, whereas *P. edgerleyi*, which has leaves that pass through similar stages but are larger and bright green, grows sparingly on the lower hill slopes. (In Allan's *Flora of New Zealand.* Vol. I, *P. colensoi* and *P. simplex* are placed in the genus *Neopanax.*)

P. crassifolius (p. 11; Fig. 6) is a small tree remarkable for its stiff, narrow juvenile leaves; it is replaced in the subalpine belt by the smaller, more bushy *P. linearis. P. anomalus* is a small-leaved, twiggy shrub of damp, frosty flats. It can be distinguished from other divaricating shrubs by its umbels and the

distinct joint between its short leaf stalk and the leaf blade.

Pseudowintera colorata (pp. 12, 98, 119; Fig. 12). A small tree, common in lowland and montane forests, growing mainly in gullies and river flats.

Pteridium aquilinum var. *esculentum* (p. 7). The common bracken fern, distinguised by its long rhizomes and rather tangled, branching fronds with hard, narrow ultimate segments.

Pteris macilenta (p. 11). A bracken with softer, broader leaf segments.

Pterostylis. A genus of mainly forest orchids with wide, soft, grassy leaves and solitary, stalked, greenish flowers. The "lip" of the flower snaps shut when touched.

Puka. *Griselinia lucida*

Pygmea ciliolata (p. 18). A soft, grey, high-alpine cushion plant related to *Hebe,* with small, sunken, white flowers.

Pyrrosia serpens (p. 16; Fig. 9). A creeping epiphytic fern.

Pygmy pine. *Dacrydium laxifolium*

Quintinia acutifolia (pp. 11, 14, 108; Fig. 5). An abundant tree on the lower hills.

Ranunculus. Herbs with five or more regularly-arranged, usually yellow petals that fall off readily. The most abundant is the introduced *R. repens* (pp. 116, 117; Fig. 30) of damp pastures and swamp margins. *R. flammula* has smaller flowers and very narrow leaves. *R. lappaceus* is a native species of lowland and montane native grassland, similar to *R. repens* but smaller with hairy leaves. The still more slender *R. hirtus* is found in well-lighted places on the forest floor.

R. sericophyllus (p.18) is a high-alpine buttercup with finely divided silky leaves. *R. godleyanus* (pp. 18, 109, 119) has much larger, shining green leaves. Two of the alpine species have white flowers: the noble *R. lyallii* (pp. 13, 119, 123; Fig. 48) and *R. buchananii* (pp. 18, 108) which has glaucous, divided leaves.

Raoulia (p. 17). Low-growing, almost moss-like composites with small flower heads sunken among the leaves. Most of the species in the park are herbaceous and creeping. Two species that form mats on stony flood plains (pp. 49, 70) are the silvery green *R. tenuicaulis* (Fig. 27) and the light grey *R. hookeri* which in early summer has bright yellow flowers. Alpine mat plants are the brownish green, narrow-leaved *R. subulata* (p. 18) of snow hollows and the silvery-leaved, white-flowered *R. grandiflora* (p. 18; Fig. 50) of stony grassland. Woody raoulias or "vegetable sheep" (pp. 98, 109) form hard cushions in rocky, high-alpine places, but only one species, *R. buchananii* (p. 108; Fig. 50), has been found in Westland National Park.

Rata, northern. *Metrosideros robusta*

Rata, southern. *M. umbellata*

Rata, vines. *M. diffusa, M. fulgens, M. perforata*

Raupo. *Typha orientalis*

Red tussock. *Chionochloa rubra*

Rhacomitrium (p. 49). Grey or brownish green mosses that form loose mats on dry, stony ground. When plants are wetted, the long-pointed leaves undergo violent contortions, visible under a hand lens.

Rhopalostylis sapida (p. 11). The only native palm, abundant along the West Coast southwards to Greymouth and thence very sparingly to the mouth of the Poerua River near Harihari.

Ribbonwood, lowland. *Plagianthus betulinus*

Ribbonwood, mountain. *Hoheria glabrata*

Ribbonwood, shore. *Plagianthus divaricatus*

Rice grass, bush. *Microlaena avenacea*

Rice grass, mountain. *M. colensoi*

Rimu. *Dacrydium cupressinum*

Ripogonum scandens (pp. 12, 70; Fig. 2). An abundant lowland vine often forming dense thickets of tough, smooth canes.

Rubus. Slender-stemmed woody plants with small prickles on their twigs, leaf stalks, and midribs. The scrambling, introduced *R. fruticosus* (p. 117) is regarded as a serious weed. Three of the native species are tall lianes. *R. cissoides* (p. 12; Fig. 10), with bright green leaves, is widespread in lowland and montane forest. *R. schmidelioides* has narrow leaves which are often whitish beneath and grows mainly in young forest developing on river flats. *R. australis* has marbly green, oval leaflets and grows in lowland forest on wet ground. The dwarf *R. parvus* (Fig. 27) is described on p. 177.

Ruppia (p. 88). A slender water plant rooted in the mud of lagoons.

Rush. See *Juncus, Luzula, Marsippospermum.*

Ryegrass. *Lolium perenne*

Sagina procumbens (p. 87; Fig. 34). A small glabrous, creeping chickweed.

Salicornia (p. 88). A tufted, salt-tolerant plant with leafless, succulent, jointed stems.

Samolus repens (pp. 87, 89; Fig. 35). A wiry coastal herb, forming mats or tufts, with regular, five-petalled, white flowers 6-8 mm across.

Schefflera digitata (pp. 49, 54, 122; Fig. 22). The sole New Zealand representative of a large tropical genus of tree ivies.

Schizeilema. Low-growing umbellifers distinguished from the related hydrocotyles (q.v.) by their fruit being square in cross-section instead of flattened. The high-alpine *S. haastii* (p. 18) is by far the largest and most striking, whereas species such as *S. nitens* (p. 119) are delicate creeping plants on damp ground at lower altitudes.

Schoenus pauciflorus (p. 14; Fig. 49). A loosely tufted sedge with dark green, wiry stems which superficially resemble those of *Marsippospermum gracile,* though more slender. As well as growing in high-altitude grassland, it also trails on damp rocks to low altitudes. *S. nitens* (p. 89) is a small, stiff, rhizomatous plant of damp hollows in lowland grassland.

Scirpus. An extremely diverse group of sedges. Leaves, if present at all, are often rounded and stem-like. The spikelets are often aggregated into a dense mass at the top of the stem, and, in some, the uppermost leaf looks like a continuation of the stem, with the flower head seeming to project from the side.

The giant of the genus is the 2-m tall *S. lacustris* (p. 88); *S. americanus* (p. 88) and *S. nodosus* (p. 87; Fig. 35) are rather shorter coastal plants. Remaining species in the park are very small (p. 75). *S. cernuus* forms light green tufts on coastal rocks and *S. habrus* likewise on bouldery river banks. *S. reticularis* forms loose patches on damp, shaded mud and has the odd habit of producing new plants from buds in its seed heads, as does the larger *S. prolifer. S. aucklandicus* commonly forms mats around the edges of alpine tarns, while *S. subtilissimus* (p. 89) grows in lowland and coastal turf.

Sea musk. *Mimulus repens*

Sea primrose. *Samolus repens*

Seaweeds. Mentioned on p. 86.

Sedge. See *Carex, Carpha, Cyperus, Desmoschoenus, Eleocharis, Oreobolus, Schoenus, Scirpus, Uncinia.*

Selliera radicans. Described under *Pratia* (q.v.)

Senecio. The largest genus of flowering plants and a most variable one. New Zealand has about 24 shrubby species, but only one, *S. bennettii* (p. 13), grows in the park. *S. scorzoneroides* is a beautiful alpine herb, unfortunately much reduced by browsing mammals. Its tufted, grassy leaves are unremarkable, but in flower it produces masses of heads, each up to 5 cm across with long, white rays. *S. bellidioides* has rosettes of bristly, heart-shaped leaves and bright yellow flowers and in the park has only been found in one locality on the piedmont hills. Other species include the tall straggling, native *S. minimus* (p. 20; Fig. 21) and the introduced *S. jacobaea,* the pretty but toxic ragwort of lowland pastures.

Shield fern. *Polystichum vestitum*

Silver pine. *Dacrydium colensoi*

Silver tussock. *Poa laevis*

Sisyrinchium "chilense". A tiny, blue-flowered introduced iris found on lowland river flats.

Snow algae. Described on p. 75.

Snow-tussock, broad-leaved. *Chionochloa* cf. *flavescens*

Snow-tussock, narrow-leaved. *C.* cf. *rigida*

Snow-tussock, pale-leaved. *C. pallens*

Sonchus. See under *Cirsium*

Sophora microphylla (p. 47). A small tree with delicate pinnate leaves and pendent golden flowers in spring. In Westland, it grows only near estuaries, the seed being transported by coastal currents.

Speargrass. *Aciphylla*

Sphagnum (p. 53). Pale green bog mosses that form thick, spongy hummocks retentive of water.

Sprengelia incarnata. A heath mentioned on p. 99.

Stellaria. A genus of glabrous chickweeds that includes the common garden species (*S. media*), an introduced species of wet, grassy hollows (*S. graminea*), and a few inconspicuous native plants including *S. gracilenta* (p. 109; Fig. 27).

Stereocaulon. A "shrubby" lichen of rocky banks, described on p. 55.

Suaeda maritima. A coastal succulent.

Sundew. *Drosera*

Supplejack. *Ripogonum scandens*

Tangle fern. *Gleichenia circinata*

Taraxacum spp. See under *Hypochoeris*

Thelymitra. Orchids with a subterranean bulb from which springs a rather fleshy leaf and a raceme of blue or white flowers. *T. venosa* is one of the showiest plants of the pakihis. *T. longifolia,* which is up to 50 cm tall, grows on open, grassy slopes but is seldom common.

Thistle. See *Cirsium*

Three-finger. *Pseudopanax colensoi* var. *ternatus*

Tmesipteris (p. 96; Fig. 9). A primitive relative of the ferns and club-mosses.

Todea. Large, tufted forest ferns with finely divided, dark bluish-green, membranous fronds with small, round spore-capsules scattered over the back. *T. hymenophylloides* has the frond segments all lying in the same plane, whereas *T. superba* (p. 123), surely one of the most beautiful of ferns, has the frond plume-like through crimping of the segments.

Toetoe. *Cortaderia richardii*

Toro. *Myrsine salicina*

Totara, Hall's. *Podocarpus hallii*

Totara, snow. *P. nivalis*

Totara, Westland. *P. totara* var. *waihoensis*

Tree ferns. See *Cyathea, Dicksonia*

Trentepohlia (p. 49). Botanically, a "green alga", in which the chlorophyll is masked by a bright orange pigment.

Trichomanes. A genus of filmy ferns (Hymenophyllaceae, q.v.) *T. reniforme* (p. 12; Fig. 8) is an anomalous, thick-leaved member, with creeping stems and characteristic, bright green, kidney-shaped leaves 5-8 cm across.

Trifolium (p. 47). The true clovers, with small, dense flower heads and tiny, straight pods The species of the park are the white-flowered *T. repens* (p. 116), the pink-flowered *T. pratense,* and the yellow-flowered *T. dubium.* See also *Lotus.*

Trisetum antarcticum (p. 117; Fig. 49). A graceful, loosely tufted grass found mainly on the floors of mountain valleys. The related *T. youngii* (p. 117) has denser heads through the panicle branches lying closer to the central stalk.

Turpentine shrub. *Dracophyllum uniflorum*

Tutu. *Coriaria*

Typha orientalis (p. 71). A plant of swamps and shallow lakes recognisable by its tall, narrow, rather fleshy leaves and naked stems to 3 m tall ending in dense, cylindrical flower heads.

Ulex europaeus (pp. 47, 70, 86, 87, 117). A spiny, yellow-flowered shrub abundant on lightly farmed country in most parts of New Zealand.

Umbellifer. An important family of herbs with flowers and fruit borne in umbels. It includes carrots, parsnips, celery, and parsley as well as many native plants.

Umbrella fern. *Gleichenia cunninghamii*

Uncinia. Leafy, tufted sedges in which the seed cases are prolonged into long, hooked, clinging bristles. There are at least 18 species in the park, and even specialists find some of them difficult to identify. The largest form either clumps of relatively wide leaves and dense, dark brown heads, these being abundant on tracks and slips through the forest (e.g., *U. uncinata),* or dense tussocks of narrow leaves and narrow, sparse heads on river flats (e.g., *U. egmontiana). U. divaricata* (p. 121; Fig. 48) is a medium-sized species which grows in open, stony areas from the montane to the alpine belt.

Small uncinias grow on various sites to as high as the limits of vegetation. One forest species, *U. filiformis,* has leaves so narrow as to be thread-like.

Urtica ferox. A rather dangerous native nettle which forms a sparsely branched shrub, to 2 m tall, armed with vicious, 5 mm-long stinging hairs. It is still very localised in the park, but further north in Westland it has become abundant in forest margins damaged by deer or cattle. *U. incisa* is a herbaceous nettle that is not uncommon in lowland forest.

Utricularia novae-zelandiae (p. 50; Fig. 25). A small, insect-catching plant of lowland boggy places, with blue-petalled, yellow-centred flowers.

Vegetable sheep. See *Raoulia*

Verrucaria. A coastal lichen mentioned on p. 86.

Viola. The three native violets all have predominantly white flowers and heart-shaped leaves. The tufted *V. cunnginhamii* is abundant in alpine grassland. *V. lyallii,* which grows mainly in lowland swamps, is very similar but has creeping stems. *V. filicaulis,* also with creeping stems, grows in lowland and montane grassy places; its leaf margins are more prominently notched than those of the other species.

Vulpia myuros. See under *Festuca*

Wahlenbergia pygmaea. A rhizomatous plant abundant in stony alpine grassland with rosettes of small leaves and slender stems bearing single, nodding white or blue bell-like flowers. Two other species are coastal and scarce in the district.

Water fern *Histiopteris incisa.*

Weinmannia racemosa (pp. 11, 12, 14, 15, 49, 53, 86, 107, 122; Fig. 6, 8). The most abundant tall broad-leaved tree in the district.

Weymouthia (p. 16; Fig. 9). A epiphytic moss.

Willow-herb. *Epilobium*

Wineberry. *Aristotelia serrata*

Winteraceae. (p. 98). The primitive character of this family of small trees in shown in the simple structure of the flowers and in the wood which resembles that of conifers rather than other flowering plants because it lacks the large tubular cells known as vessels.

Wire-rush. *Calorophus minor*

Wolffia (p. 74). A tiny flowering plant that consists of green, floating discs.

Yellow-silver pine. *Dacrydium intermedium*

Yorkshire fog. *Holcus lanatus*

Zostera muelleri (p. 88). A flowering plant that forms grass-like swards in strongly brackish water, such as at the southern end of Okarito Lagoon.

Recent Changes in Latin Names of Plants

NAME USED	NEW NAME
Angelica montana	Gingidia montana
Asplenium falcatum	Asplenium polyodon
Blechnum fluviatile	Blechnum chambersii
Calorophus minor	Empodisma minus
Cerastium holosteoides	Cerastium fontanum *subspecies* triviale
Cyathea *spp.*	Alsophila *spp.*
Elytranthe	Peraxilla
Freycinetia banksii	Freycinetia baueriana *subspecies* banksii
Haloragis depressa	Gonocarpus aggregatus
Lotus pedunculatus	Lotus uliginosus
Phymatodes diversifolium	Phymatosorus diversifolius
Podocarpus dacrydioides	Dacrycarpus dacrydioides
Pygmea ciliolata	Chionohebe ciliolata

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Glossary

The following list includes mainly words which are not adequately defined in a standard dictionary, such as the "Pocket Oxford".

Abbreviations: the only abbreviations likely to be unfamiliar to the general reader are the following which are used in conjunction with Latin binomials of plants.

- sp. Following a generic name, this indicates a species, for which the specific name is unknown or not cited.
- spp. Plural of sp.
- cf. Coming between the generic and specific names, this indicates that the plant is not exactly the same as that indicated by the Latin binomial, but no closer approximation is available.

Alluvium: gravel, sand, or silt deposited by a stream.

Anaerobic: condition where atmospheric gases, especially oxygen, are absent or nearly so.

Awn: a bristle protruding from the chaffy scale of a grass flower.

Binomial: the Latin name for a plant or animal, the first word indicating the genus, the second the species.

Bract: modified leaves, closely associated with flowers. In some plants, such as the everlasting daisies, bracts are enlarged and conspicuous and assume the role of petals.

Bryophytes: mosses and liverworts.

Cirque: natural amphitheatre carved out by a névé (q.v.).

Climax: the stage in succession (q.v.) when vegetation reaches maximum stability, mass, and complexity (see p. 49).

Divaricate: to branch repeatedly at wide angles. The habit is characteristic of many native small-leaved shrubs and juvenile trees.

Epiphyte: a plant that lives perched on others, without parasitising them.

Flora: either the complement of plant species in an area, or a book that describes these species.

Föhn: a warm dry wind which blows down mountain valleys and slopes.

Gallery forest: that confined to strips on either side of a stream flowing through flat terrain.

Gley: a waterlogged soil (see p. 49).

Greywacke: sandstone which has been hardened and slightly modified chemically by heat and pressure.

Hardwood: dicotyledonous tree; this includes all New Zealand trees except conifers, tree ferns, palms, and cabbage trees.

Kame terrace: gravel terrace deposited by a stream flowing at the side of a glacier.

Leaflet: a segment of a compound leaf such as that of clover, kowhai, or pate.

Liane: a climbing plant.

Névé: expanse of permanent snow and ice at the head of a glacier.

Obcordate: refers to a leaf that is heart-shaped, but attached to its stalk by the point.

Opposite: refers to paired leaves, one leaf being on the opposite side of the stem from the other.

Outwash gravels: those deposited by streams issuing from glaciers.

Pakihi: this denotes a marshy tract with heathland vegetation, sometimes induced by burning and sometimes natural.

Parent material: the unweathered rock or sand etc. underlying the soil and giving rise to it.

Panicle: a type of inflorescence or flower head in which the primary branches from the central axis divide further into smaller branchlets which bear the flowers.

Periglacial: severe environment that prevails near borders of large icefields.

Piedmont: relatively flat lowland at the foot of a mountain chain and mainly derived by erosion of the latter.

Photosynthesis: the process by which leaves use energy from sunlight to synthesise sugar from carbon dioxide and water.

Pinnate: a compound leaf with the leaflets arranged, feather-like, along either side of a central stalk.

Podzol: a mature soil with a leached upper mineral layer and an enriched lower layer (see p. 48).

Raceme: an inflorescence with a central axis, to which the individual flowers are attached by short stalks.

Regular: referring to geometrically regular flowers, with sepals, petals, etc. of equal size and shape.

Rhizome: an elongated, underground stem bearing roots along its length.

Rhizomatous: plants with rhizomes.

Roche moutonnée: a mound of bare rock which is usually smoothed on the upstream side and steepened on the downstream side as a result of glacial movement.

Scarp: a steep slope which cuts across and thereby exposes the strata. Scarps often result from earthquake rupture.

Serrate: referring to leaves with sharply and regularly toothed margins.

Sorus: an area on a fern frond (usually on the undersurface or margin) where the spore-cases are concentrated.

Spike: an inflorescence with a central axis, to which the individual flowers are attached directly, without intervening stalks.

Spikelet: the spike of a grass or sedge. In grasses especially, spikelets are small, compact, and specialised and usually themselves arranged in higher-order inflorescences such as spikes or

panicles.

Succession: refers to the succession of plant communities (as well as soils and animals) of increasing mass and complexity on surfaces which are initially bare. "Primary" successions begin on mineral surfaces or in waters which have not previously supported life. "Secondary" successions begin where existing soil and vegetation have been incompletely disrupted, as by fire, for example.

Talus: sloping deposit of fragmented rock which accumulates at the foot of a mountain or on ledges.

Umbel: an umbrella-shaped inflorescence in which the flower stalks radiate from the end of a central axis.

Vascular plants: the ferns, clubmosses, conifers, and flowering plants, all of which have wood or fibrous tissue with an advanced anatomical structure.

General Index

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